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Topics of the Month

Cancer in the chemical industry

FOR the past five years the chemical industry has been conducting an investigation into the cause and prevention of papilloma of the bladder among workers engaged in the manufacture of dyestuffs. The investigation, which has cost £25,000, has been carried out under the auspices of the Association of British Chemical Manufacturers. A full-time research officer, Dr. R. A. M. Case, has been employed and help has been given by the Chester Beatty Research Institute of the Royal Cancer Hospital. Dr. Case's chief duty has been the carrying through of an industrial field survey of the occurrence of bladder tumours in workmen engaged in the manufacture and use of certain compounds used primarily in the dyestuffs industry. The enquiry has been focussed on three compounds—*alpha*- and *beta*-naphthylamine and benzidine. It is now possible to state with confidence that occupational exposure to these three substances causes an increased death certification of tumour of the bladder. While the risk of contracting a tumour of the bladder from a mixed exposure to all three substances is about 33 times that of the population at large, the risks associated with exposure to *beta*-naphthylamine are 61 times that of the population at large. There is no evidence at all that the manufacture or use of aniline causes bladder tumours.

Those employed in the manufacture of either magenta or auramine dyes also showed increased liability to death from bladder tumour, although less than in the case of the other three substances. The investigation did not reveal the nature of the causative agent in either of these cases, but it must not be assumed that the finished products are necessarily harmful.

So far the investigation has had two important results. First, the manufacture of *beta*-naphthylamine in Great Britain has been stopped completely. Second, papilloma of the bladder has been added to the list of prescribed industrial diseases, so that industrial injury benefits will be payable to persons suffering from it. The people likely to be affected are those whose work involves them coming into contact with *alpha*- or *beta*-naphthylamine, benzidine or any of their salts and those engaged in the production of auramine or magenta.

Designing safe processes and plant

THE A.B.C.M. research scheme on papilloma of the bladder is described in a booklet published by the Association and available to those with close interest in the problem. Of especial importance is that section dealing with the design of processes and plant in order to prevent contact between workers and carcinogenic solids, liquids, solutions or vapour. Wherever possible, plant should be totally enclosed, there should be extremely good ventilation and there should be a high standard of cleanliness by the avoidance of sp llages.

In some cases it has been necessary to scrap old plants which could not be made safe and to build, at considerable expense, new and safe plants employing the most up-to-date methods of handling dangerous materials. In designing new

plants and buildings the following principles are of prime importance:

Workrooms should be large, airy and well ventilated. Floors should be easily drainable.

No wood or other absorbent material should be used which can become contaiminated in case of an accidental spillage.

If the dangerous material has to be handled in the molten condition where it is liable to give off dangerous vapour, especially good exhaust ventilation should be used on the containers and this should a so apply to plant such as drying stoves.

Manual handling of powders or pastes should be avoided as far as possible by the use of mechanical filters and similar plant.

Wherever possible, the carcinogenic material should be delivered to the user-plant as a slurry or solution and further processed to a harmless stage without separation of the solid carcinogen.

Wherever it is necessary to separate the solid in the dry or paste form for sale to other users, the greatest care must be taken to avoid dust in the packing operation. Wooden casks, which could absorb the dangerous material, should preferably not be used or, if they must be used, they should be thoroughly washed immediately after use without steaming or heating.

There is also a risk which must be looked for and guarded against in subsequent manufacturing operations in which the toxic starting material is converted into a new product or derivative which in itself is quite harmless. If the conversion of the starting material is not complete, small quantities of unchanged carcinogen may remain in the final product with potential danger to workers exposed for long periods to this final product. Appropriate analytical control enables this possibility to be defined so that precautions can be taken.

Air venting—a neglected practice

CONSIDERING its simplicity and the possibilities it affords of increasing output, it is surprising that automatic air venting is far from being the general practice in process steam plant. In *The Efficient Use of Steam* (H.M.S.O., 1947), Oliver Lyle instanced a double-effect evaporator whose first body dropped mysteriously from 18 in. vacuum to atmospheric pressure, owing to the vent on the second calandria having been inadvertently closed. In *Steam Trapping and Air Venting*, L. G. Northcroft also gave some striking figures: textile drier heating-up time reduced from 90 to 10 min.; jam boiling time reduced by 30% and the steam consumption reduced by 20%; all accomplished by proper venting.

The fuel-saving potentialities of air venting are obvious. In the recent ' British Productivity Report on Fuel Conservation ' only a passing reference is made to the subject; this is because developments in this field are much the same in the U.K. as in the U.S.

We were reminded of these and several other arguments in favour of the wider use of automatic air venting to overcome the bad effects of even small percentages of air in the steam spaces of plant by a short article in *Chemical Topics*, published by Spirax-Sarco Ltd. The reluctance to adopt air venting is curious, for its advantages have been known for so long. Indeed, the first patent for a double-effect evaporator, taken out by Rilleux 110 years ago, showed air vents on both steam jackets.

More use must be made of new coking processes

AFTER years of chronic shortage, Europe should balance its coal budget this year. The O.E.E.C. Coal Committee estimates that 1954 output should reach 488.3 million tons. This will still not cover estimated consumption of 498.5 m. tons but the deficit can be made up fairly easily by drawing on stocks. Generally, therefore, there will be a balance between supply and demand and there should be no need to turn to America for coal. However, this general picture tends to be deceptive, for there are shortages of special grades such as coking coal and anthracites. The coking programmes call for a further 8.5 m. tons of coking coal between 1952 and 1954. Even if coal output comes up to estimate and the same percentage is earmarked for coking purposes, no more than 3.5 m. extra tons of coking coal will be available. The deficit must be made up by technological means. Action must be taken to make more use of the new coking processes which enable coal with a high volatile content to be used in coke ovens and thus reserve a larger proportion of output for coking than in previous years. Unless these measures are taken, recourse will have to be had to American supplies, assuming, of course, no serious decline in iron and steel production.

There is very little scope for increasing production of anthracite and the solution of this deficit lies in the use of other kinds of solid fuel, in particular semi-coke and coke of small calibre unsuitable for the iron and steel industry.

Fog, smoke and chemicals

THE Government committee on air pollution, under the chairmanship of Sir Hugh Beaver, who, incidentally, is a chemical engineer, issued its interim report last month at a time when fog and smoke and the hazardous combination of the two—' smog '—were very much in the news. The Ministry of Health had just announced its scheme for issuing smog masks free under the National Health Service and there were lively differences of opinion about the efficacy of these masks and, indeed, whether they should be used at all.

The Beaver committee's report does not add much to our knowledge of smoke pollution. It reiterates that the open domestic fire is the biggest smoke producer; nearly half of the 2.1 million tons of smoke emitted in 1952 came from domestic chimneys. In some cases the proportion from home fires is even higher; 60% of the smoke which contributed to the heavy London smog of December 1952 came from domestic fires. However, industry is not, by any means, blameless in this matter and there are still far too many factories using fuel inefficiently and not taking measures to reduce smoke emission. For instance, fire doors which eliminate smoke have been devised by the Fuel Research Station, but only a few of the 40,000 to 50,000 hand-fired boilers in this country have been fitted with them. It is clear that stronger measures will have to be taken to enforce more efficient fuel usage and the reduction of smoke emission. Apart from the health hazards of smoke, on the material side vast damage to metals and building materials results from the corrosive acids formed from the sulphur in fuels. The total cost to the community may be more than £100 million a year, apart from the cost of wasted fuel which smoke represents.

To turn from the Beaver report, chemists and chemical engineers will be interested in two new approaches to the smog problem: (1) the production of smokeless coals and

Corrosion: a New Series of Articles for Chemical Engineers

CORROSION is a constant and costly problem of industry generally. Just how costly cannot be assessed with accuracy. The staggering figure of £2,000 million annually has been given as the cost of corrosion in the United States. In Britain, a figure of £200 million has been put forward by the British Iron and Steel Research Association, who derive it from an estimate of the cost of painting all the steel produced annually in this country. This, of course, is only a partial estimate, since it does not take into account the costs of corrosion of other metals. However, it is alarming enough.

No industry has more formidable corrosion problems than the chemical industry. At all stages of his work the chemical engineer is concerned with preventing or minimising corrosion. He will seek to do this in several ways. At the design stage he will recall that protection against corrosion should begin on the drawing board and try to avoid such obvious errors as unnecessary contacts between dissimilar metals. Linked with design is the choice of materials and also the question of environment.

Corrosion inhibitors will also be considered and such improvements as the duplex inhibitors developed in the corrosion laboratories at Teddington and Cambridge will no doubt be borne in mind. Cathodic protection is another method of reducing corrosion which, although applied chiefly to underground pipelines, might prove to be of great benefit in cases of immersed corrosion. Dr. W. J. H. Vernon has pointed out that in the U.S. cathodic protection is being employed on a very large scale for the protection of water tanks, for which sacrificial anodes are commonly used. Finally, there is the very big subject of protective coatings, ranging from traditional tar coatings to modern coatings such as zinc-rich paints.

Although corrosion in its several aspects presents many unsolved problems and much scope for large-scale research, it is questionable whether all or even a substantial part of existing knowledge is applied by industry. As proof of this we may quote the journal Petroleum Processing, *which recently estimated that American oil refiners could save annually $45 million, or 20% of the direct cost to them of corrosion, by the application of methods for corrosion protection* now *proved to be practicable. It is hardly likely that the chemical industry could make proportionately fewer savings by intelligent and wider use of existing corrosion knowledge.*

To make the chemical industry more corrosion-conscious, we shall shortly begin a series of articles on corrosion and the chemical engineer. They are being written by Dr. L. L. Shreir, of the Metallurgy Department, Battersea Polytechnic, London. He will begin with first principles in an article on the electrochemical principles of corrosion. In his next article he will deal with the extremely interesting subject of corrosion and design. Cathodic protection, inhibitors, coatings, corrosion-resistant alloys, etc., and many other aspects of modern corrosion knowledge will be covered in subsequent articles.

the reduction of smoke from boilers and (2) the dispersal of fog by chemicals. The British Utilisation Research Association are investigating the first approach. They have discovered that coal can be made substantially smokeless by pre-treatment with nitrogen oxide at 300°C. or higher and with nitric oxide or nitrogen dioxide at or above room temperature. This treatment itself is unlikely to be commercially practicable, but it indicates a possible promising line of research. The smoke-reducing process involves the use of a bank of refractory tubes coated with platinum-alumina catalyst. This catalyst is made in the U.S. by Houdry Co. and it is soon to be made here. It is claimed to effectively reduce the amount of smoke and unburnt gases in industrial boilers and furnaces; however, it is expensive.

The chemical-fog-dispersal scheme has been devised by Mr. N. Pilpel, of King's College, University of London, and it has been submitted to the Beaver committee by Sir Eric Rideal, chairman of the Scientific Advisory Council of the Ministry of Supply. Mr. Pilpel proposes that a very dilute solution of cheap detergent mixed with traces of 'rain-making' chemicals (*e.g.* silver iodide, dry ice or salt) should be sprayed into the fog from aircraft. This, he claims, would make the tiny water droplets of which fog is composed to flow together until their size and weight make them fall as rain. Polluting agents in the fog would be dispersed as well.

Seeding agents spread into cold clouds drive the supercooled water droplets together as snow, and then the clouds snow or rain themselves away. However, this happens efficiently only if the temperature is 10°C. or more below zero. Fog clouds are not cold enough to be cleared in this manner and, therefore, the seeding agents must be reinforced. Surface-active agents, it is suggested, make it easier for water droplets to flow together and for snow to clump. The quantities needed for fog clearance would be small. It is possible that surface-active agents might be effective even without seeding chemicals.

Platinum in industry

CONTRARY to the popular belief that the platinum metals are used mainly for jewellery and similar luxury articles, more than 75% of the output of these noble metals is used in industry. This fact was emphasised in the exhibition held in London recently to commemorate the discovery of palladium by William Hyde Wollaston, the London physician, in 1803. Palladium was the second of the group of platinum metals to be discovered, platinum itself having been known since the 16th century. Rhodium was also identified by Wollaston, and osmium and iridium by Tennant, his English contemporary. Ruthenium was the last to be discovered in 1840 by Claus, a Russian chemist.

The industrial utility of the platinum metals results from their high melting points and great resistance to corrosion and oxidation. Workability, which varies greatly among the six metals of the group, also determines their respective fields of use. The two most abundant, platinum and palladium, are ductile and malleable. Rhodium and iridium, on the other hand, can be worked only with difficulty and it is not yet possible to work ruthenium and osmium satisfactorily.

In the chemical industry the platinum metals are mainly used as catalysts. An important example is the employment of platinum catalysts for the oxidation of ammonia for the production of nitric acid and nitrates, and in synthesising high-octane petrol from crude oil.

Palladium catalysts are used in the production of fine chemicals such as dihydro-streptomycin, produced by hydrogenating streptomycin in the presence of a palladium catalyst supported on alumina. Another important application of a palladium catalyst is in gas purification, especially the removal of traces of oxygen from hydrogen.

Palladium also has the unique property of acting as a filter for hydrogen. If impure hydrogen is fed under pressure to one side of a palladium membrane at a temperature of 200°C. the hydrogen diffuses selectively through the barrier and may be drawn from the low-pressure side almost free from impurity.

Platinum has a high oxygen overvoltage and is not dissolved anodically by direct-current electrolysis in aqueous solution, hence platinum electrodes are extensively employed in electrolytic processes such as the manufacture of hydrogen and peroxide persulphates. In the viscose rayon industry, rayon filaments are formed by extruding a strongly alkaline viscose solution through a number of fine holes in a spinning jet into an acid coagulating bath. The holes, of which there are several thousand in a large staple fibre jet, must remain accurate and highly polished during a long period of service. Alloys of gold and platinum or gold, platinum and palladium, have proved the most suitable for this purpose.

Platinum crucibles are normally employed in the manufacture of optical glass. Platinum is the only metal which does not contaminate the glass and has at the same time sufficient strength at the working temperature of about 1,400°C. Platinum is used, too, for the dies and measuring orifices of equipment for making bottles and other glassware and in the bushings used in the manufacture of glass fibres by extrusion.

East German chemical plant

THE East German chemical plant industry appears to have made a strong recovery, judging from its showing at the recent Leipzig Fair. It is clear that chemical plant will be an increasingly important export of East Germany, particularly now that reparations to Russia have come to an end and, consequently, more industrial products will be available to other countries. The East Germans are making vigorous efforts to sell to under-developed countries and are prepared to sell complete plants and the know-how needed to run them. They are willing to send technologists to start up industries in foreign countries. Delivery dates are described as good and prices are claimed to be competitive.

Exhibits at Leipzig included plants for the production of phenol, soda, nitric acid and synthetic resins. Equipment for sugar-cane and sugar-beet factories was also offered; in the latter case the plant available can produce as much as 3,000 tons/day of sugar. Among the newer plants in the exhibition was an oxygen generator with a capacity of 1,500 cu.m./hr. It is made by Chemische Maschinenbauwerke, of Rudisleben.

Chemical stoneware plant is an East German speciality. There are 22 factories producing ceramic equipment ranging from pipes to thousand-litre storage vessels and drug milling plant.

Equipment for the production of toilet and household soap, equipment for the paint industry, for household and trade refrigeration plants, air-treatment installations and machinery for the food and drink industries were also exhibited. In fact, there seems to be little in the normal range of chemical and ancillary plant that is not manufactured in Eastern Germany.

Iron from nickel ores

THE valuable iron content of nickel ores is rejected in slag or tailings in currently-used extraction processes. Ferro-nickel production, in which iron is an undesirable impurity, results in the recovery of only a minor portion of the ore's iron content. Now, however, the recovery of iron ore as a by-product of the nickel extraction process has been made commercially practicable by a new process and, at Copper Cliff, in the Sudbury district of Ontario, Canada, the International Nickel Co. of Canada Ltd. are beginning construction of a $16-million plant as the first unit in an operation which will ultimately yield about 1 million tons p.a. of high-grade iron ore in addition to nickel. Containing at least 65% iron and less than 2% silica, the ore will go to the Canadian and U.S. steel industries, which are at present largely dependent on imports from countries such as Brazil, Venezuela, Sweden and Liberia for ore of such a high grade.

Initially the plant will treat 1,000 tons/day of nickel-bearing pyrrhotite removed from ore in the early stages of processing at Copper Cliff. It will make possible the treatment of lower-grade Sudbury ores, hitherto considered uneconomical. The new process is expected to open the way for increased recovery of other elements from the complex nickel ores, including sulphur when its production becomes economically feasible.

The case for high chemical tariffs in the U.S.

THE slogan, 'Trade not Aid,' in America has raised once again the question of tariff reduction. High chemical tariffs have long caused complaints from chemical manufacturers trying to sell to the U.S. and, naturally, there is considerable interest in whether the latest debate will result in lower tariffs. If the Manufacturing Chemists Association has its way, there will be very little reduction, if any, in these controversial tariffs. The M.C.A. represents 130 manufacturers who account for more than 90% of U.S. chemical output. It is thus a powerful body and the Commission on Foreign Economic Policy, in Washington, will treat its views with respect.

The M.C.A.'s arguments for keeping chemical tariffs high are put out in a long statement which gives an interesting American view of British and European chemical industry. 'Our European allies now have strong and growing chemical industries and it is entirely appropriate that they should. They also have capacities far in excess of their own needs and export up to 50% of production, in contrast with the U.S. consumption of 96% of its chemical output.' It is argued that American chemical prices are higher than European because American wages are generally three to six times those of labour abroad, and even highly efficient American producers cannot compete with European firms in price. Furthermore, European producers are accused of returning to the old pre-war cartel system. 'There is a high degree of concentration of the chemical industry among a few companies. For example, in the U.K. two companies control 85% of the production of organic chemicals; in France two companies produce 95% of its output of these materials; in Italy two firms account for 80% of capacity; in Western Germany four companies produce substantially all the chemicals. By contrast, sales of the three largest American chemical companies amount to only about 15% of aggregate domestic chemical industry sales.'

High tariffs, it is argued, are necessary to protect the American chemical industry and the national economy from competition resulting from cartels.

From Ethyl Alcohol to CELLULOSE ACETATE

Australia's New Chemical Industry

A new £4½-million factory for the manufacture of cellulose acetate has been opened at Rhodes, New South Wales, by C.S.R. Chemicals Ltd. The process starts from the basic raw material, ethyl alcohol, and continues through acetic acid and acetic anhydride to the final cellulose acetate flake which is supplied to Courtaulds (Australia) Ltd. for rayon manufacture. C.S.R. Chemicals also operates an older factory producing ethyl alcohol and its derivatives. With the new factory, therefore, the company has a complex of plants producing not only the raw materials for cellulose acetate but also several other organic chemicals, many made in Australia for the first time.

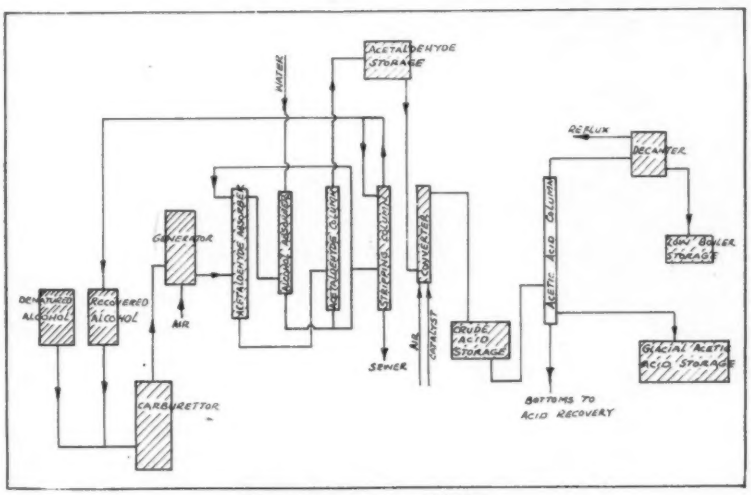
C.S.R. CHEMICALS is a joint enterprise of Colonial Sugar Refining Co. Ltd. and the Distillers Co. Ltd., and was established in January 1952 with a capital of £6 million. The association between the two parent companies began in pre-war days. Both wished to extend their interests in industrial fermentation through the development of chemical industries based on alcohol, so they decided to work in partnership.

In 1939, they each bought shares in Robert Corbett Pty. Ltd. Corbett's factory at Lane Cove (Sydney) was engaged in the manufacture of acetic acid, ethyl acetate and metallic soaps. This company formed the basis on which the two parent companies began the development of chemical manufacture in Australia.

At Lane Cove, almost immediately, construction began on a plant to produce acetone and butanol from the fermentation of molasses. Then, in 1942, an American-designed plant was erected for the production of acetic acid from the fermentation of alcohol.

During the war a Government annexe was built next door to Corbett's factory.

General view of the plant at night.

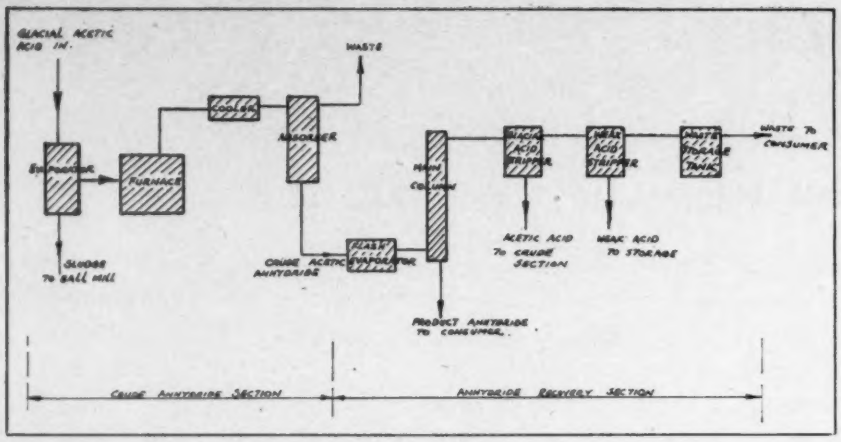


Flow sheet, acetic acid plant

This plant was for the production of synthetic acetone and was run for the Government by Colonial Sugar Refining. In 1948 the annexe was bought by Corbett's and in the same year construction began on two new plants, one for producing synthetic acetic acid and the other for the continuous production of ethyl and butyl acetate. Both plants started operation in 1950.

In 1951 the company opened a phthalate plasticiser plant, and in the same year extensions to the acetone-butanol plant (built in 1939) doubled its production capacity.

On the administrative side, Colonial Sugar Refining took over the management of Corbett's in 1947. Early in 1952, C.S.R. and D.C.L. bought out the remaining shares in Corbett's and thus became joint owners of the company, C.S.R. holding 60% and D.C.L. 40% of the



Flow sheet of crude acetic anhydride plant.

shares. At the end of the same year, Robert Corbett Pty. Ltd., through a transfer of shares, became a wholly-owned subsidiary of C.S.R. Chemicals Pty. Ltd.

During this period, Colonial Sugar Refining had been investigating the manufacture of chemicals starting from ethyl alcohol as a base. Early study led to the company's decision to explore thoroughly the manufacture of cellulose acetate and related chemicals. The new plant at Rhodes is the outcome of this research.

The factory site lies between the railway and Homebush Bay, with an entrance right next door to Rhodes railway station. Before the foundations for the new factory could be laid, there were old foundations to be removed and the sloping land had to be levelled into terraces. A sea wall was built, and earth was removed from the site and built into Homebush Bay. In this way, 12 extra acres were reclaimed from the bay, to make a total site area of about 30 acres. Site preparation began in September 1947 and, early in 1948, foundations were laid for the first building construction. Altogether 180,000 cu. yds. of earth were moved and the total cost of site preparation approached £100,000.

Well over 90% of the constructional work was carried out in Australia by the combined effort of Colonial Sugar Refining Co. specialists and local engineering firms. An engineering workshop was set up at Rhodes to carry out some of the highly skilled detail work and to co-operate with outside contractors.

Raw materials

Although some of the raw materials are imported, the main basic ones are derived from Australia's sugar-growing and refining industries. These are: sugar, molasses and ethyl alcohol produced by the fermentation and distillation of molasses.

At Lane Cove, molasses and ethyl alcohol provide the bulk of the raw material used. At Rhodes, ethyl alcohol is the starting material for the industrial chemicals. Vapour-phase oxidation of alcohol produces acetaldehyde which, in turn, is oxidised to make acetic acid. Glacial acetic acid is used to produce acetic anhydride by the ketene process. The next step is the production of cellulose acetate, and this requires some imported raw materials. Cellulose, in the form of wood pulp or cotton linters, has at present to be imported from overseas. The cellulose is treated with acetic acid and reacted with acetic anhydride to produce cellulose acetate flake. This is the basis for the manufacture of acetate rayon.

Cellulose acetate plastic moulding powders are produced at Rhodes from the flake by the application of other Australian materials, namely phthalate plasticisers from the Lane Cove factory and colour pigments. At Rhodes the manufacture of fine chemicals starts either from sugar or from starch, which itself comes from Australian wheat.

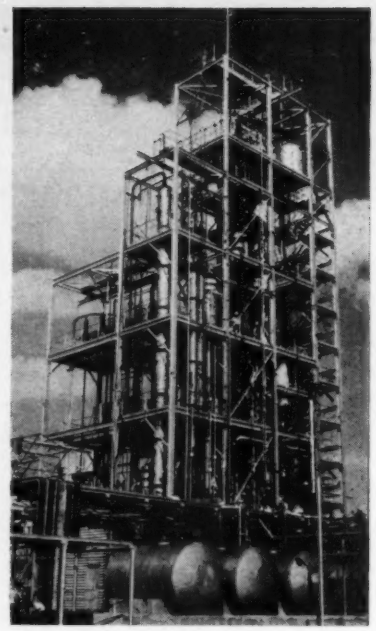
The two main Australian resources for these industries are therefore: sugar cane, a natural asset that renews itself constantly with the seasons; and oxygen from the atmosphere. Together, the Rhodes and Lane Cove plants will produce some 30 synthetic organic chemicals.

However, the main development at present is the new Rhodes factory for the manufacture of acetic acid, acetic anhydride and cellulose acetate, and it is these plants which are described in this article.

Acetic acid

The acetic acid plant represents a development of the type of plant common to the petroleum industry, in that all units are out of doors with centralised control rooms. The entire plant is equipped with a high degree of instrumentation and, consequently, it is possible to operate it with the minimum of manpower, one man per shift being sufficient.

The process is carried out in two stages. In the first stage, ethyl alcohol is reacted with oxygen from the air to form acetaldehyde. In the second, the acetaldehyde is reacted with oxygen from the air to form crude acetic acid, which is refined to produce glacial acid.



Anhydride distillation and acid recovery plant. Six of the battery of tanks are connected with the anhydride plant and one with the acid recovery plant.

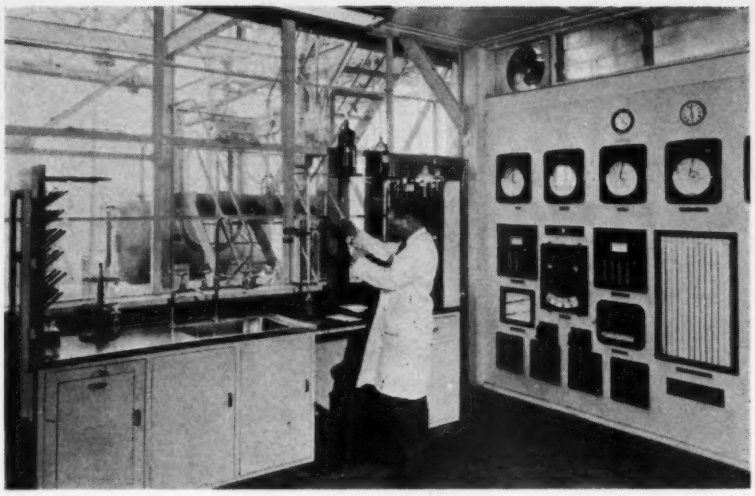
Ethyl alcohol from the Pyrmont distillery of C.S.R. is blended with alcohol recovered from the process and used as raw stock feed. The blended alcohol is converted to acetaldehyde in a reaction vessel containing a silver catalyst. Cooling and fractionation are then carried out.

The acetaldehyde produced in the first stage is reacted catalytically in two stainless-steel converters to give crude acetic acid. This is eventually pumped to the final distillation column, where water (representing 6% of the material) and the catalyst are removed from the product. The glacial acid is taken off the base of the distillation column in the vapour phase, condensed, cooled and stored.

Crude acetic anhydride plant

The manufacture of crude acetic anhydride may be separated into two stages. In the first, strong acetic acid, over 99%, is vaporised at reduced pressure, mixed with a phosphate catalyst and passed through a cracking furnace to yield ketene and water, according to the equation $CH_3COOH = CH_2CO + H_2O$. In the second stage, the ketene gas is reacted with acetic acid in four packed towers in series to yield acetic anhydride, $CH_2CO + CH_3COOH = CH_3CO:O:OCCH_3$. This reaction, which is exothermic, is almost complete after the second tower, the last two towers being primarily to remove spray before the inert gases are passed over to the vacuum pump. Acetic anhydride, with 15% acetic acid, is continuously removed from the first absorber circuit and sent through to the distillation plant.

The crude acetic anhydride plant, like



Control laboratory, acetic anhydride plant. Here the purity and grade of the crude product is continuously checked.

the acetic acid plant, is an outdoor one with a central control room. A high degree of instrumentation enables the equipment to be operated by one process worker. Most of the equipment is built of stainless steel, with some storage tanks in aluminium and barometric sealed tanks in copper. Special provision has to be made here, as in the acetic acid plant, to prevent the freezing of the acetic acid in the winter months, and to this end all lines carrying acetic acid are steam-traced with an external low-pressure small-diameter steam line lagged in common with the pipe being traced.

An important factor in the design of this plant is the protection of the cracking coils, which are of special material, against high temperature and against excessive cracked-gas temperature. To this end, alarms are provided and provision is made for the furnace to be automatically shut down should the safe limit temperatures of the equipment be exceeded.

Acetic anhydride distillation plant

This is an outdoor plant and is combined with the plant for the recovery of weak acetic acid received from the cellulose acetate plant. It is, nevertheless, quite independent of the acetic acid recovery section and can be operated separately.

Brown crude acetic anhydride—a mixture of 85% acetic anhydride and 15% acetic acid—is received into the plant through two aluminium storage vessels. From here it is pumped into the first distillation circuit, where the major proportion of tarry matter is removed. The mixture is then fed to the main copper distillation column for recovery of the anhydride and acetic acid.

This column is of the bubble-cap type. The heads material, which is glacial acetic acid with a small percentage of acetic anhydride, is used as the reflux for the column, with a constant bleed-off to a small third column which is used for stripping heads material before return to the crude anhydride plant for use as part of the scrubbing acids in the absorption circuits. In this plant, the weak acetic acid, which is one of the by-products from the crude acetic anhydride plant, is also passed into another stripping column where the heads material is removed and the weak acetic acid passed over to the acid recovery plant for final recovery as glacial acetic acid.

Acetic acid recovery and concentration

The acid recovery plant, which forms part of the third outdoor plant on the site, is used for the recovery of weak acetic acid, which is one of the returned materials from the cellulose acetate process.

The first operation is the stripping of a small fractional percentage of methylene chloride which appears in the weak acetic acid. The base liquor from the methylene chloride stripper is passed continuously over to a liquid-liquid extraction column where solvent extraction of the acetic acid takes place. Ethyl acetate is used as the solvent and the extract material passing from the top of the column comprises approximately 84% ethyl acetate with 8% acid and 8% water. It is stored in a feed tank for final distillation.

Cellulose acetate manufacture

Cellulose acetate is a product of the reaction between cellulose and acetic anhydride leading to the triester. In order to be of greater interest commercially, the triacetate is hydrolysed to a wide range of secondary acetates depending upon the end use. The main chemical reactions involved are:

Acetylation

$$C_6H_7O_2(OH)_3 + 3(CH_3CO)_2O \longrightarrow C_6H_7O_2(COCCH_3)_3 + 3CH_3COOH$$

Hydrolysis

$$C_6H_7O_2(OOCCH_3)_3 + nH_2O \longrightarrow C_6H_7O_2(OOCCH_3)_{3-n}(OH)_n + nCH_3COOH$$

Many attempts have been made to acetylate directly to the acetyl value desired without first preparing the triacetate followed by hydrolysis, but no successful work has ever been reported. Similarly, it has not been possible to hydrolyse satisfactorily the cellulose triacetate as anything but a solution, although numerous attempts have been made to hydrolyse in fibrous form.

Pre-treatment of cellulose

The first step in acetylation is to prepare the cellulose in a form susceptible and easily accessible to the acetylating agents. The cellulose, after purification from its native state, is unreactive to direct acetylation because of the collapsed nature of the fibre, and must be pre-swollen for proper ingredient penetration. In actual commercial practice the cellulose used to prepare cellulose acetate is derived from cotton linters or wood pulp. Cotton linters are the short fibres remaining on the cotton seed after ginning, and should not be confused with the long staple used in cotton textiles. The cotton linters, after purification, are packed in 200-lb. bales. Wood pulp, after its purification, is prepared as a continuous sheet, rolled into 500-lb. packages. Upon receipt, the cotton linters and wood pulp will usually contain about 6% moisture.

The bales of cotton linters are handled on pallets and fork trucked to the picker room. The cotton linter bales are unwrapped, weighed and conveyed to a cotton bale picker which opens up the bale and prepares the cotton in a light fluffy form which is transferred pneumatically to a large vessel called the pre-treater. Wood pulp rolls are mounted on a weigh stand and the sheets are continuously fed to a pulp picker which disintegrates the sheet and pneumatically blows the picked pulp to the pre-treater. From this point on, the process for lint or pulp is similar.

To swell the fibre, acetic acid is added to wet the cellulose and, when pre-treatment is complete, the swollen cellulose is pneumatically blown from the pre-treater on ground level to the acetylator located on the fifth floor.

Acetylation process

Once pre-treated and conveyed to the acetylator, the cellulose is ready for esterification and the ingredients are therefore added after being carefully measured. All ingredients are stored at ground level and are pumped up to the upper floors when required. Ingredients for the acetylation reaction are cellulose, acetic anhydride, methylene chloride and a catalyst. In the process at Rhodes, methylene chloride replaces the acetic acid used in the older acetylation methods. The use

of methylene chloride allows for more economical preparation of cellulose acetate as well as the production of a superior-quality product, permitting at the same time modern chemical engineering principles to be used to great advantage.

Since the acetylation catalyst used is usually sulphuric acid, several other chemical reactions are known to occur in various degrees, such as:

$$C_6H_7O_2(OH)n + nH_2SO_4 \longrightarrow C_6H_7O_2(SO_4H)_n + nH_2O$$

$$(CH_3CO)_2O + H_2SO_4 \longrightarrow CH_3COSO_4H + CH_3COOH$$

$$C_6H_7O_2(OH)_n + n(CH_3COSO_4H) \longrightarrow C_6H_7O_2(OOCCH_3)n + nH_2SO_4$$

$$C_6H_7O_2(OH)n + n(CH_3COSO_4H) \longrightarrow C_6H_7O_2(SO_4H)_n + nCH_3COOH$$

$$C_6H_7O_2(SO_4H) + nCH_3COOH \longrightarrow C_6H_7O_2(OOCCH_3) + nH_2SO_4$$

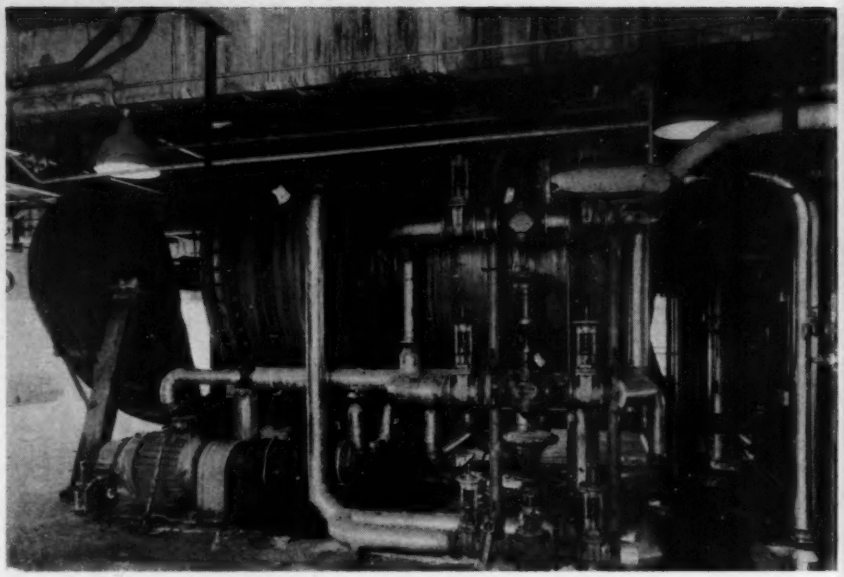
The acetylation reaction is exothermic with about 597 B.Th.U. liberated per lb. of cellulose esterified, and much of the success of the operation depends upon careful temperature control. Cooling is achieved by a water jacket on the acetylator as well as vaporisation, condensation and refluxing of methylene chloride back to the acetylator.

The cellulose gradually esterifies and becomes soluble in the methylene chloride which is an excellent solvent for the triester. Acetic acid acts as a co-solvent, but little acetic acid besides the pre-treatment acid is added, the balance being introduced as a by-product of the acetylation reaction. When the cellulose is completely esterified, a fibre-free, viscous, honey-coloured solution of cellulose triacetate is obtained. When the solution reaches a desired viscosity, water is made to react with the excess acetic anhydride in the system. The water prevents further degradation of the cellulose acetate produced and also provides the –OH groups for the subsequent hydrolysis to the secondary acetate.

The triacetate dope is dropped by gravity from the acetylator to the hydrolyser located on the floor below. Here the acetyl groups are to be replaced by –OH groups in order to produce an acetate of a predetermined acetyl value. Again catalyst is added, usually sulphuric acid, and control of temperature is again maintained in order to provide the proper conditions for hydrolysis.

When the desired acetyl content is reached, the acid catalyst is neutralised, otherwise the reaction could continue to produce eventually a regenerated cellulose. The methylene chloride is then distilled from the dope, and weak acetic acid or water is added to precipitate the hydrolysed product.

The precipitation produces cellulose acetate in small lumps and spent acetic acid. The acid is drained from the acetate and pumped to the acid recovery plant where it is converted to glacial acetic acid to be re-used in pre-treatment. The excess glacial acetic acid is converted to acetic anhydride in another plant on the site.



Acetylator, showing part of drive system and automatic temperature control equipment.

The acetate is wet milled to reduce the particle size, and drops into a mill receiver which is on ground level. The acetate flake is slurried in this receiver and pumped to a series of treating tubes at the same level, where the flake is washed acid free and stabilised. With purification complete, and approval given by the laboratory, the acetate flake slurry is pumped to the top floor of an adjacent building where it is continuously dewatered in a centrifuge. The flake drops to a drier feed hopper and then to a rotary vacuum drier for drying to a low moisture.

After drying, the flake is pneumatically transferred to a series of bins located in the blending and storage building close by. Here it awaits laboratory analysis before final disposition is made. The flake can be either packed out as an individual batch, or it can be blended off into huge blends for textile consumption and transferred to its destination in bulk by truck. Facilities are also available to further reduce the particle size if desirable.

Operating conditions

Various materials of construction are utilised throughout the process, depending upon the ingredient to be handled. Stainless steel is extensively employed, but bronze, aluminium, glass-lined steel and galvanised iron are also used. Most of the equipment was fabricated on the site in extensive shop facilities, and many novel features of construction were developed which are considered superior to standard methods.

The buildings are of steel and concrete construction, with brick exterior for the most part, in compliance with the local building codes, and flooring is acid resistant where required. Considerable instrumentation and automatic control are evident throughout the installation.

The product from beginning to end is handled in a closed system to prevent fumes from penetrating the working areas, to maintain pleasant conditions for the personnel, to prevent ingredient losses and to produce the highest-quality product.

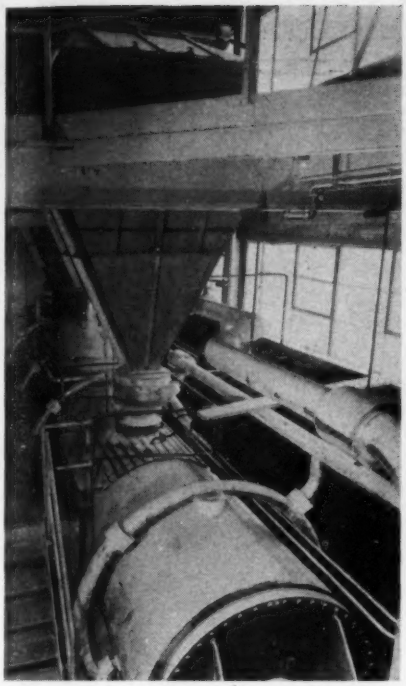
The factory has been designed as much as possible to add comfort and safety to personnel. Despite the closed system, fume removal facilities have been added to eliminate nuisance fumes during certain operating and maintenance periods. Vessels are isolated electrically and liquid or vapour lines are blanked off to offer the man the utmost security should he be required to enter the vessel. Safety showers, fire extinguishers and respirators are located at strategic areas for emergency use.

Blending, storage and pulverising plant

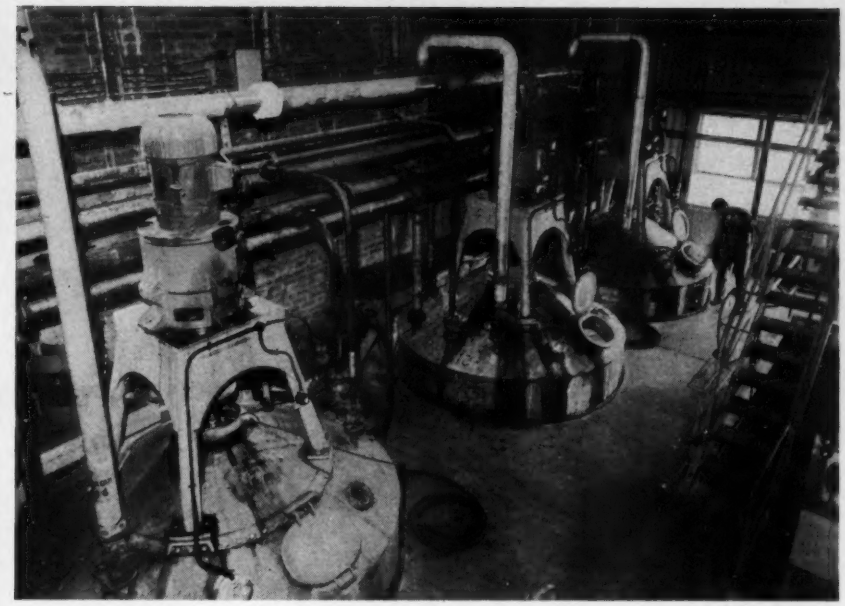
Cellulose acetate manufacture is essentially a batch process and, although all batches are maintained well within the customer's specification, it is still desirable to smooth out variations among batches by a blending process. A comprehensive blending plant has been installed in the Rhodes factory which ensures that both textile and plastic grades of cellulose acetate flake can be supplied to customers' requirements, and close tolerances maintained within their specifications.

For textile grades, blending makes a contribution to absolute uniformity of vital characteristics such as viscosity and combined acetic acid value.

On the local market there are fewer outlets for textile grades than for plastics types and, at present, volume production



Vacuum drier. Flake comes in from the loading hoppers (above the drier) which are fed from a centrifuge.



Three of the eight purification tubs which are used to wash and stabilise the cellulose acetate flake.

of textile grade at Rhodes is confined to one specification for Courtaulds (Australia) Ltd., whereas some 30 different varieties are being made for use in *Celsior* moulding powders. In addition to blending for viscosity and acetyl value, further blending may be necessary to achieve the correct colour in plastic grades.

The blending plant consists of three sets of bins, two of which are fitted with proportioning measures, with the third set acting as bulk storage for textile-grade material.

A batch of cellulose acetate flake, having been dried in the vacuum drier and checked as meeting specification, is transferred pneumatically to an Avery batch weighing machine mounted above the primary bins. This weigher is connected to the primary bins by means of chutes and two turnspouts, so arranged that the contents of the batch weigher can be discharged into a selected bin.

A system of chutes and flap valves connect the proportioning measurers to the 24 primary bins in such a way that a satisfactory selection is possible for blending into either rayon or plastic grade sections. In the case of the rayon grade material, blending of the flake from a selected number of bins in a manner determined by the setting of the measures, is carried out in a screw conveyor. For plastic grade acetate, blending is effected in a pneumatic conveying system which transfers the primary blend to the secondary bins. If necessary, rayon grade flake can be transferred to these bins for a secondary blending in the same manner.

From many of the secondary bins the primary blend can be further mixed with material from other secondary bins in predetermined proportions, and discharged into either the rayon or plastic grade systems. Here again, rayon grade material is mechanically conveyed, whereas plastic grade flake is pneumatically conveyed. The reason for using pneumatic handling in this instance is to minimise the risk of contamination with metal particles or atmospheric dust from unfiltered air which would form undesirable specks in the final moulded product. The requirements for textile acetate flake are not quite so critical in this particular respect, because the flake is dissolved in acetone and subjected to a thorough filtering before the spinning operation.

Material for blending from either the primary or secondary bins (or both) is conveyed to bulk storage by a system of conveyors and elevators. Bulk storage consists of two galvanised-steel silos arranged so that the cellulose acetate can be constantly recirculated through them by means of an elevator and flow controlling measurers. This recirculation ensures a uniform composition for sale and makes certain that minute changes do not occur in the quality as supplied from day to day.

The final product is at present delivered to Courtaulds at Tomago by means of a road tanker filled from a packing-out hopper. This hopper is charged with the correct amount by means of an elevator from the bulk bins.

For moulding powder manufacture, the cellulose acetate flake is pulverised and screened. Plant for this operation consists of conventional *Hummer* vibrating screens and a *Mikro* pulveriser. The pulverised material is automatically weighed into containers of 50-lb. capacity or multiples thereof.

Moulding powder plant

The ingredients of the moulding powder, which include cellulose acetate, a plasticiser, colouring materials and stabilisers, require to be incorporated together to a uniform mass suitable for subdivision later to granular form as needed by the moulding industry.

To arrive at this uniform mass, the process may be divided into two separate stages, namely the preliminary mixing stage followed by the homogenising or 'colloiding' stage. Both of these operations may take place in the one or in separate units, depending on the type of process used. In the preliminary mixing stage the process is the relatively simple one of stirring together measured amounts of the required ingredients. Both ribbon- and paddle-type stirrers have been found satisfactory. As the mixture is non-corrosive, the choice of materials of construction is fairly broad, although stainless steel is the preferred material. The product after mixing is a relatively free-flowing and apparently dry material.

For the colloiding stage there is a choice of three main processes: roll milling, Banbury mixing and extrusion. C.S.R. Chemicals has chosen the extrusion process as being best for the purpose.

For colloiding by the extrusion process, the powdery mass from the preliminary mixer is fed to the extruder hopper. In passing through the extruder the temperature of the mass is raised, while at the same time a milling action takes place due to the relative motion of the screw and extruder barrel. By the time the material

(*Concluded on page* 19)

HEAT TRANSFER

Recuperation, regeneration, fixed beds, transpiration cooling, fluidised beds, boiling evaporation, condensation, radiation

By J. Moss, B.Sc.

SINCE the last review, 'Heat transfer phenomena' by Bosworth[1] has been published in Australia, Britain and the U.S.A. This book is based on the opening paper of a conference on heat transfer in 1948 at Sydney. It is a review of recent developments in all the major aspects of heat transfer including the use of electrical and other model methods. A unified presentation is achieved by treating the flow of heat as an example of a transport process in which one or more physical characteristics of a molecular assembly may be transferred from point to point by the movement of certain 'carriers.' The book is clearly set out and there are many recent references. However, the line diagrams, though clear, are crudely drawn.

Nusselt[2] on the occasion of his seventieth birthday wrote an interesting article on the historic development of the theory of heat transfer.

In studying recent literature, it is remarkable how much heat transfer data of interest to chemical engineers is being produced in other fields.

Conduction

The thermal conductivities of fibrous glass insulation varying in density from 0.5 to 8.4 p.c.f. have been measured by Verschoor and Greebler.[3] By varying the gases in the insulation and also the gas pressure they found that gas conduction was the most important heat transfer mechanism. A theory was developed which conformed with their results. The conductivity of some insulating powders and fibres has also been investigated by Deissler and Eian.[4] Martin[5] has discussed all the factors affecting the selection of low temperature insulation for refinery service; his remarks apply also to other industries. High temperature granular refractory materials have been examined by Atterton[6], who determined the effect of numerous variables on the apparent thermal conductivity of the compacted powders from 20-1600°C. Nusselt's steady state concentric sphere method has been used by Kozak[7] to determine the conductivity of silica gel and graphite powders in the temperature range 100-600°C.

The determination of the conductivity of soil under various climatic conditions, has been the subject of three recent papers. Mason and Kurtz[8] have described an apparatus for the rapid determination of the thermal resistivity of soil *in situ*. A hole was drilled into the soil and an electrically heated needle containing a thermocouple inserted. By plotting time temperature readings on semi log paper the soil resistivity was determined by measuring the slope of the graph. Two papers were presented by Higashi[9, 10] on the thermal conductivity of frozen soil. The first paper was primarily concerned with the design of the apparatus used in the subsequent measurements. In the second paper was described the determination of the conductivity of samples of frozen soil prepared artificially under conditions simulating natural frost formation. Samples were investigated exhibiting the two modes of ice segregation, an ice plate, and several dispersed layers.

Tyler and Wilson[11] have measured the thermal conductivity, from 20 to 300°K, of artificially extruded graphite, natural moulded graphite, and lampblack graphite. Marshall[12] has used a flat plate type of apparatus to measure the conductivity of several typical cable dielectric materials over their working temperature range.

Schmidt's method for determining temperatures attained by various thicknesses of solid sheets during heating and cooling has been adapted by Bott[13] for calculating the degree of vulcanisation of sheets of soft rubber.

A survey of experimental data and theoretical extrapolation methods for the conductivity and Prandtl Number of air has been made by Glassman and Bonilla.[14] Using a conductivity cell which overcame inaccuracies due to radiation etc., they have extended the high temperature range of the experimental data. Keyes[15] has made additional measurements of the conductivity of N_2, CO_2, and mixtures at higher temperatures. The measurements show unexpected deviations from values predicted on the basis of the linear composition proportionality. An electric hot wire method was used by Aly[16] to measure the conductivity of air, SO_2 and H_2S, from 0-50°C.

Apparatus for measuring the thermal conductivity of high pressure gases has been designed by Michels and Botzen.[17] It is based on the parallel plate method, and an accuracy of 1% is claimed. Junk and Comings[18] have measured the conductivities of N_2-ethylene and CO_2-ethylene mixtures, their comparison of the results with theoretical predictions show deviations of the order of 5% and 36% respectively.

Both this paper[18] and a previously mentioned one[15] show the danger of relying on theoretically derived values for the conductivities of gas mixtures. A new equation has been suggested by Franck[19] connecting the thermal conductivity with the specific volume and heat of highly compressed gases. This has been used to predict the conductivity of gaseous NH_3 up to 60 kg./cm.^{2} and 150°C.

A method of avoiding the guard ring in heat conductivity measurements of plate shaped bodies has been described by Schmidt.[20] It was made possible by making additional measurements of the surface temperature of the plate. A method permitting the rapid simultaneous determination (2-3 mts.) of conductivity, temperature conductivity coefficient, and volumetric heat capacity of a poor heat conductor, has been used by Volkenshtein.[21]

The following papers are concerned with theoretical solutions of heat-conduction problems.

Poppendiek[22] has made an analytical study of the thermal structure of citrus fruits artificially heated by radiant orchard heaters. He compares his theoretical solutions for the variation of the temperature distribution with time, with experimental results obtained with oranges.

Both Goldenberg and Tranter[23] and Zatzkis[24] have obtained mathematical solutions of the problem of heat flow in a medium surrounding a sphere, when heat is generated in the sphere. This problem is related to the disinfestation and sterilisation of biological materials by differential heating by high-frequency fields. A problem arising during investigation into the 'end effect' in cylindrical thermal conductivity probes led to the mathematical solution by Blackwell[25] of the radial-axial heat flow in regions bounded internally by circular cylinders.

Prins *et al.*[26] have obtained solutions for the temperature distribution at the end of an electrically-heated wire.

For their solution of a non-linear problem in transient heat conduction involving temperature-dependent thermal properties, Beutler and Knudsen[27] claim an improve-

ment in accuracy over other methods up to 10% for the unaccomplished temperature change.

The merits of various finite difference methods of solution of heat-flow problems have been examined by Price and Slack[28] from the viewpoint of stability and accuracy.

Convection fundamentals

The temperature and velocity distribution in the wake of a heated cylinder have been measured by Berry *et al.*[29] for air speeds up to 90 ft./sec. Values for the heat transfer from the cylinder were also determined. An extension of the work of Jakob and Dow on the heat transfer between a cylinder and air flowing parallel to its axis has been carried out by Tessin and Jakob.[30] They investigated the influence on this system of unheated starting sections. Cary[31] has measured the local heat-transfer coefficients on the surface of a sphere in the range of Re number from 44,000 to 151,000. The results can be correlated by expressing the relation between the Re and Nu numbers as a function of the angle from the stagnation point. Variations of the convective heat losses with different air velocities for vessels of different shapes and sizes has been studied by Kapadnis and Gogate.[32]

Making the assumption that the temperature variation across the boundary layer is similar to the velocity variation, Donaldson[33] has derived theoretical relations for heat transfer and fluid friction in turbulent incompressible and compressible boundary layers along a flat plate. The heat loss from a plate in a compressible and viscous gas was investigated theoretically by Cole and Wu.[34] Ostrach[35] used an integrated heat-flow equation to determine exact solutions of the free convection heat transfer on a vertical plate. The effect of surface roughness on the heat transfer from a flat plate was examined by Sato and Sugawara.[36] The objective of Scesa and Sauer[37] was to obtain turbulent, forced, convective heat-transfer data for air flowing parallel to a flat plate with a stepwise discontinuous surface temperature. The surface was heated by transverse *Nichrome* ribbons each separately controlled. Their results could be correlated by the Colburn equation within $\pm 6\%$ for Re number from 60,000 to 800,000, using the starting length correction of Rubesin. The differential equations for heat transfer from vertical plates were extended to include inclined plates by Rich.[38] He concluded, after experiments with angles of inclination from 0 to 40° from the vertical, that the use of Grashof number, modified by the cosine of the angle of inclination, could predict the conductances to within 10%. Levy[39] has calculated how the transfer coefficient along the boundary layer varies with surface temperature, and Millsaps and Pohlhausen[40] have solved the heat-transfer problem for the laminar boundary layer of a rotating plate.

The convective heat-transfer and flow-friction characteristics of small tubes of circular and rectangular cross-section have been examined by Kays and London.[41] They found that the performance of the rectangular tubes agreed closely with that of the circular tubes. But they were markedly different in laminar and transition flow, where the aspect ratio had an important effect.

A study of the effect of entry and exit conditions and length to diameter ratio on the heat transfer to air flowing through heated tubes has been made by Chu and Storrow.[42] Measurements of temperature gradients, velocity distributions, etc., in a turbulent air stream in a ducting have been described by Schlinger *et al.*[43] Reese and Graham[44] have measured the heat transfer to nitric acid in tubes subjected to conditions similar to those in rocket motors. The wall temperature distribution in polygonal passages were calculated by Eckert[45] for the turbulent flow of fluids having a Prandtl number near 1.

More and more papers are devoted to the investigation of problems involving high and supersonic gas velocities. Seban and Drake[46] have determined the local heat-transfer coefficients and recovery factors for an elliptical cylinder in a high-speed air stream. Both Van Driest[47] and Janssen and Young[48] have made a theoretical investigation of the heat-transfer and -friction processes occurring in laminar boundary layers for Mach numbers up to 10. An approximate analysis was presented by Drake and Backer[49] for the prediction of overall average heat-transfer coefficients from spheres to a rarefied gas in supersonic flow. The conditions considered were those in the transition region where the mean free molecular path is small but not negligible compared with the sphere diameter. Experiments were described by Saunders and Calder[50] on the measurement of the heat transfer in a nozzle for Mach numbers up to 1.75. The nozzle was water cooled and the gases were at 850°C.

Kubanskii[51, 52] has published two papers dealing respectively with the flow near a heated solid body in a standing sound wave and the effect of acoustic vibrations of finite amplitude on the boundary layer. He found it possible to increase the heat-transfer coefficient by up to 50% and he considered the use of sound waves to control the amount of heat transfer to be feasible.

Another subject which is attracting ever-increasing attention is the study of the heat transfer to liquid metals. Hyman *et al.*[53] have measured the natural convection heat transfer between horizontal cylinders and 14 liquids, including seven liquid metals. They correlated their results by plotting the Nusselt *versus* the Grashof-Prandtl number. The heat-transfer coefficients for liquid mercury and dilute solutions of sodium in mercury have been measured in forced convection in a water-jacketed double-pipe exchanger, by Doody and Younger.[54] The coefficients approximately doubled when the small quantity of sodium was added. Heat transfer in the turbulent flow of lead bismuth eutectic through tubes has been investigated by Johnson *et al.*[55]

Bonilla *et al.*[56] determined the heat transfer to slurries of chalk and water in turbulent flow in pipes. Effective conductivity was considered to be that of the water, and the specific heat as the average of the constituents; these values were used in comparing results with theory. An investigation into the heat-transfer characteristics of pseudo-plastic fluids was carried out by Ju Chin Chu *et al.*[57] Liquids examined were latex, vinyl plastic emulsions and dilute polymeric solutions.

Recuperators

Schmidt[58] has used non-dimensional groups to define the characteristics of heat exchangers and to aid heat-transfer calculations. The solution of a commercial problem involving heat exchange between air, N_2 and O_2, using an analogue computer, has been described by Paschkis and Heisler.[59] Dubois-Violette[60] has applied the method of fusion of roots to the study of the stability of the automatic regulation of a heat exchanger, and showed that the efficiency of the regulation was improved by a derivative control system. Lynch[61] has solved the differential equation for the heat transfer from an exchanger to a batch of fluid in a tank, for either multipass or cross-flow exchangers.

Experimental results on heat transfer and fluid friction during flow across banks of tubes have been used by Bergelin *et al.*[62] for a further study well into the zone of turbulent flow; this is part of a long-term research programme on this subject and a very wide range of variables has been covered. By changing the position of one electrically-heated tube in ten rows of alternate five and six tubes, Snyder[63] has determined the heat-transfer coefficients of all the tubes for a series of air velocities. He correlated his results by plotting Nu *versus* Re.

Flat plate and shell and tube types of heat exchanger have been operated by Tidball[64] using sodium and sodium potassium alloys for both short and long periods. The temperature level was about 1,000°F.; they discovered no fouling after 75 weeks of operation. The performance of finned tubes in shell and tube heat exchangers has been measured by Williams and Katz[65]; they found that the heat transfer for clean finned tubes was 110% of the plain tube for water and 200% for lube oil. London *et al.*[66] have presented part 3 of their work on the heat-transfer and flow-friction characteristics of compact heat-exchanger surfaces, in which they give design data for five types of surface, bringing the total number of surfaces investigated by them to 39.

The effect of turbulence on the heat

transfer in a pile with a liquid reactant has been examined theoretically by Parker.[67] He concluded that the total heat transfer decreased with an increased spacing of the cooling surfaces. But this disadvantage had to be set off against the advantage of decreased parasitic neutron losses to the coolant. The problem of the effect of various sizes and arrangements of rotors and baffles on the heat-transfer coefficients in liquid mixing has been investigated by Dunlop and Rushton.[68] Hausmann[69] has described apparatus for heat exchange at high temperatures and pressures.

Regenerators

Gas-turbine developments have led to research into the operation of rotary regenerators, and some of this data is now being published. The design and performance of an extended surface regenerator for a gas turbine has been described by Holm and Lyerly[70]; it was developed for a gas-turbine plant for a natural-gas pipeline pumping station. A comparison of typical solutions for determining rotary regenerator performance has been presented by Harper and Rohsenow,[71] who showed the effect of leakage on regenerator effectiveness and plant performance. Bowden and Hryniszak[72] have dealt with the influence of a regenerative air preheater on the performance of a simple open-cycle gas turbine. Formulae were given relating the regenerator dimensions and matrix materials with the condition of minimum fuel consumption. Coppage and London[73] have summarised the design theory of periodic-flow regenerators. The advantages in principle of this type of regenerator over other types of regenerators or recuperators for exchanging the exhaust gas heat of a gas turbine were considered. An algebraic solution of the special case of high rotative speeds was shown to be exactly the same as that for a direct-transfer-type counterflow exchanger.

Fixed beds, porous media, transpiration cooling

In their investigation of the heat transfer to air passing through a 1-in. diameter packed tube, Chu and Storrow[74] found that in the flow ranges studied the length of the packing was an important variable. Payne *et al.*[75] have described several systems involving direct countercurrent heat exchange between solids and gases. The paper illustrates the importance of factors other than heat-transfer coefficients in the design of equipment involving countercurrent heat exchange between gases and solids. The temperature distribution and the transport of heat and mass during the regeneration of a catalyst bed have been studied theoretically by van Deemter[76] on a much simplified model permitting a complete mathematical solution.

Morrison and Rogers[77] have discussed the significance of the flow patterns for initial convection in porous media. They point out that the flow patterns could only be explained by modifying the fundamental flow laws. In a later paper, Rogers[78] propounded a theory for predicting the mean thermal gradient at the onset of convective flow of fluid in a porous medium heated from below. A numerical method for dealing with the case of porous heat sources was presented in a general form by Schneider[79] and then applied to two specific cases: of a porous power-producing cylindrical pipe and a porous power-producing plain wall.

Kinney[80] has shown that a wall under the influence of a high-temperature gas stream may be cooled by ejecting a liquid through a slot in the wall which evaporates downstream of the slot. Calculations of local heat-transfer coefficients around transpiration-cooled cylinders of arbitrary cross-sections have been made by Eckert and Livingood.[81]

Fluidised beds

From theoretical considerations, van Heerden *et al.*[82] have proposed a mechanism to account for the high rate of heat transfer in fluidised beds. They say that in its heat-transfer properties the fluidised bed is equivalent to a well-stirred liquid in which the interstitial gas serves only as a stirring agent and as a heat-transfer medium between adjacent particles and the wall. Similar interpretations of this mechanism have been made by Peters *et al.*,[83] who suggest the term 'heat-transfer capacity' for the effective thermal conductivity of the bed, and Trawinski,[84] who also discussed the influence exercised by the homogeneity of fluidisation. Temperature and humidity measurements of air in and above a drying fluidised mass of silica gel have been given by Heertjes *et al.*[85] They showed that perpendicular to the flow of air the temperature of the silica gel is practically equal to the air temperature, and that mass and heat transfer occurs in a very small layer only. Toomey and Johnstone[86] have also measured the heat transfer between beds of fluidised solids and the walls of the container. Jakob[87] has attempted to explain a discrepancy between the observations of Dow and Jakob and van Heerden *et al.* in 1951. One was concerned with cooling at the wall, the other with heating, to which factor he attributed the difference in results.

Boiling evaporation

For a detailed review of evaporation see Coulson's paper in this journal.[88] The same author has investigated the effect of the main variables such as liquor feed rate, viscosity, etc., on the heat-transfer coefficients in long-tube, climbing-film evaporators.[89]

The effect of forced circulation on the boiling heat-transfer coefficient and pressure drop in a short vertical tube was determined by Schweppe and Foust,[90] who worked up to velocities of 40 ft./sec.; they considered that at the higher velocities sonic choking was occurring in the tube. Harvey and Foust[91] derived a theoretical relation between the peak temperature attained in a long-tube vertical evaporator and the vapour head temperature. This was found to agree with the results obtained on a 20 ft. by 1¼ in. diameter evaporator tube with water boiling over a range of pressures. Heat transfer in the furnaces of water-tube boilers has been reviewed by Thurlow,[92] who concluded that the design was still rather an art than a science. A theoretical investigation of the adiabatic flow of evaporating fluids in pipes was presented by Linning,[93] who supported his theories by experiments with water in annular, separated and frothing flow. Abou-Sabe and Johnson[94] have presented tentative correlations for the prediction of pressure drop and heat transfer for the turbulent flow of air-water mixtures in a horizontal pipe.

The boiling-film coefficients of the following refrigerants have been determined by Myers and Katz[95]: *Freon* 12, methyl chloride, propane, SO_2 and n-butane. The overall heat flux from condensing steam to a boiling liquid has been measured by Jones and Loveless.[96]

Evaporation of liquids by contact with their superheated vapours has been put forward as a commercial operation by Ju Chin Chu *et al.*[97] A method of correlating heat-transfer data for the surface boiling of liquids, based on a logical explanation of the mechanism, is suggested by Rohsenow.[98]

Marx and Davis[99] have suggested that free molecule heat conduction provides the critical energy transfer preceding the collapse of the vapour blanket in the film boiling process.

Ingebo[100] has obtained the vaporisation rates and heat-transfer coefficients for nine pure liquids evaporating at the surface of a porous sphere. A new method of predicting the wet-bulb temperatures from boiling-point data and wet-bulb data for water was developed.

Tonn[101] has commented on a previous paper by Ranz and Marshall on the evaporation from drops and he discusses the techniques of measurement, etc.

Spielman and Jakob[102] have investigated the evaporation of water into an air jet blown tangentially along a wetted-plane plate, and also the effect of a dry starting section.

The applications to industrial plants of laboratory experiments on the evaporation from liquid drops and wetted plates have been discussed by Richardson.[103]

Condensation

The effects of temperature variations around a horizontal condenser tube have been examined by Bromley *et al.*[104] who concluded that errors in calculating the heat flow by Nusselt's equation, neglecting temperature variations, were negligible.

They also investigated the effect of variations in the heat capacity of the condensate and recommended the use of a modified Nusselt equation. Hampson and Ozisik[105] have examined critically the mechanism of dropwise condensation and also the life of surfaces producing such condensation. The accepted methods for the design of condensers to handle gas vapour mixtures have been reviewed by Cairns;[106] investigations were also carried out on the condensation of chloroform in the presence of air and the results compared with those calculated by several design procedures.

The mechanism of condensation of steam into low pressure hollow cone sprays of water has been studied by Weinberg,[107] who showed that a large portion of the steam condensed into the initially formed liquid film as compared with the subsequently formed drops. The design and operation of a large heat transfer installation employing *Dowtherm* A and having a rated output of 11 million B.Th.U./hr. was described by Brearley[108] with special reference to the problems presented by this particular medium.

Radiation

A paper concerned with the heat transfer from a luminous, post-aerated, town gas flame burning in a vertical water-cooled tube has been presented by Tailby and Saleh.[109] The effect of the variables: tube length, gas pressure, jet diameter, and distance separating the jet from the lower end of the tube, on the total and radiative transfer flame length, etc., were determined. Empirical equations were given relating these variables. Caution should be exercised in extrapolating these equations beyond the limits of the experimental data. No mention was made of variations, if any, of the hydrocarbon content of the gas and any subsequent effects on the radiative heat transfer. Radiation and furnace design was discussed by Gollin,[110] who referred to the furnace trials at IJmuiden. One of his conclusions was that when using flames having an emissivity from 0.5 to 1, gaps must be left round or between the flames to keep the roof at a reasonable temperature. The use of models in the calculation of fuel-heated industrial furnaces has been described by Schwarz.[111]

Radiant interchange configuration factors have been given by Hamilton.[112] Pepperhoff and Bahr[113] have discussed the variation with wavelength of the absorption constants of the suspended carbon particles in luminous flames.

Sanger *et al.*[114] have attributed the high radiation heat transfer in rocket combustion chambers to chemiluminescence.

Miscellaneous

A theoretical analysis of the problem of the temperature distribution in an inductively heated cylinder leads Thorn and Simpson[115] to the derivation of an exact expression for the inside and outside temperature difference, in terms of Bessel functions.

The conditions of heat transfer to a fusible solid in contact with a heated surface have been examined by Ross.[116]

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(*Concluded on page 20*)

The Design of Freeze-Drying Plant

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THERE seems to be much confusion of opinion in the design of freeze-drying plant as to the most advantageous geometrical arrangement which should be adopted for the disposition of the evaporating and condensing surfaces, in order to provide the most efficient conditions for the transfer of water vapour. This confusion is in no small measure due to the paucity of fundamental experimental data on the subject, though Ede (1949) has made a substantial contribution.

It is agreed that restriction to the flow of vapour from evaporator to condenser should be reduced to a minimum, though in large scale plant special requirements, such as the maintenance of sterility and the necessity for drying some biological materials in containers of specified sizes introduces unavoidable operational hindrances. It is also essential that the orifice in the drying chamber leading to vacuum pumping equipment should be adequately baffled to prevent the access of water vapour to the vacuum pumps.

Large-scale plant

The designs of large-scale plant can be roughly classified in accordance with the relative positions of evaporating and condensing surfaces into three groups; distal, medial and proximal.

In the distal type, favoured in U.S.A., the chamber containing material to be dried is connected by very wide bore pumping lines, which carry water vapour and permanent gas, to a distant separate refrigerated condenser. In view of the large gas volumes to be moved, mainly consisting of water vapour, plants of this type need pumping equipment of high capacity.

In the medial type of plant, since the condensing surface is brought nearer to the evaporating surface the capacity of the pumping equipment can be reduced. The condenser in effect acts as a pumping system in relation to the water vapour, and the holding vacuum pump need only be of a capacity and performance such as to remove permanent gas liberated from the material undergoing drying, to an extent that maintains a pressure low enough for efficient drying. The medial type of plant is exemplified by the plasma drying vessel designed by Greaves (1946). In this the coiled pipe condenser is situated at the bottom of a cylindrical chamber, and the head containing material to be dried is immediately above the condenser.

In plants of this type it is a matter of observation that in condensing the water vapour tends to form a thick ice cap over the top of the condenser coils, with extensions between the vessel walls and the outer coil of the condenser, and that the greater surface area of the inner coils is either devoid of ice or only lightly frosted. This means that only a small proportion of the total coil surface is actually available for heat transfer, on account of the directional nature of the vapour condensation path.

Design of new plant

In collaboration with Messrs. M. E. Anderson, C. M. Brain, E. C. G. Lanyon and Dr. A. J. Barnard,* I have recently been concerned in the design of a plasma drying plant which may be classified in the proximal type.

The cylindrical shell 3 ft. in diameter by 3 ft. 6 in. high, contains two condensers operating in parallel. Each condenser unit consists of a single layer tubular arrangement so constructed as to present effectively a close packed rectangular face 3 ft. high by 2 ft. wide. The two condenser units are mounted with their faces in parallel vertical planes so that in a transverse section of the chamber they appear as chords.

The drying head, which is of the conventional type for loading with transfusion bottles, drops between the two condenser units so that the necks of the two opposed stacks of bottles point outwards directly at the corresponding condenser surfaces. The clearance between the bottle necks and the condenser surfaces is $3\frac{1}{2}$ in. initally, this being reduced to $1\frac{1}{2}$ in. by the ice layer formed at the completion of a dry. The drying head accommodates 154 bottles containing in all 60 litres of plasma.

The condenser coils are cooled by direct expansion from a four cylinder $2\frac{1}{2}$ in. $\times$ $2\frac{1}{2}$ in. condensing unit operating with *Arcton* 4 (*Freon* 22), in conjunction with an electromagnetic expansion valve which provides a pulsed injection of refrigerant. The control of the valve is achieved through the opposition of a low pressure lead from the suction side of the compressor, a gas-sensitive element and a subsidiary spring-loading device. Under these conditions, with a total heat input of 1,250 watts to the drying head (8 watts/bottle), the condenser is maintained during the equilibrium period of the drying cycle at about −45°C., and as the load decreases towards the end of the drying period, the condenser temperature falls to −55°C. to −60°C. The plasma temperature during the equilibrium period is −20°C. to −21°C. The drying cycle occupies 48 hr.

The vacuum is maintained in the chamber by a small diffusion pump backed by a single stage rotary pump. The vacuum line has two branches inside the chamber each of which terminates in a special vacuum line baffle attached to the back of the condenser coils. This has been effective in preventing water vapour from entering the pumping system. The total pressure in the chamber is about 150μ during the equilibrium period of the dry falling to 30μ at the end.

Ice formation occurs predominantly on the inward surface of the condenser coils forming an almost flat sheet, the rear surface of the coils being only frosted or lightly iced. This formation makes defrosting a rapid process. After lifting out the drying head air is blown between the shell and the condenser coils, and the ice plate quickly drops off into the centre of the chamber. The ice can then be largely removed without thawing out to any great extent.

An apologia for the design of this plant can be put forward in terms of some equations developed by Ede (1949). For a constant rate of evaporation (constant heat input) and constant condenser temperature Ede showed that $\triangle P/\pi$ is a constant where $\triangle P$= vapour pressure difference between the evaporating and condenser surfaces, and π= mean permanent gas pressure in the chamber. Also if L (the distance between the evaporating and condensing surfaces) is varied then $\triangle P/\pi$ is proportional to L over a wide range.

It can be argued from these equations that it is advantageous to reduce the permanent gas pressure (π) to as low a value as possible and also bring the evaporating and condensing surfaces near to one another, though there appears to be a limiting distance below which no further advantage accrues.

There is also the danger that radiation losses may become a significant factor in decreasing the efficiency of the plant when L becomes small. In the present plant we have been about to show experimentally that during the equilibrium period of the dry, the heat loss from the head to the condenser coil by radiation is less than 50 watts which is equivalent to about 4% of the total heat input.

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*All of Messrs. J. & E. Hall Ltd., Dartford, Kent.

ULTRASONICS IN INDUSTRY

A Critical Assessment

2. Applications

By M. H. M. Arnold, B.A., B.Sc., F.R.I.C., A.M.I.Chem.E.

In the previous article, the author surveyed methods of generating ultrasonic waves—mechanical, thermal and electrical. Here he critically discusses the applications of ultrasonics. They fall into two sharply distinct classes: instrumental, where the vibrations are used to obtain or convey information; and operative, where the vibrations are used to cause changes in a system. The chemical engineer will be interested in both types of application. Examples of the first type are flaw detection and viscometry, while emulsification, wetting and dispersion, dedusting of gases and coagulation are examples of the second. Chemical and biological effects of ultrasonics are also discussed.

INSTRUMENTAL APPLICATIONS

Echo sounding and related uses

THE distance of an object which reflects ultrasonic waves may be determined by emitting a pulse of vibrations and timing the receipt of its reflection at the starting point. The most important use is that in which the reflecting object is the sea bed, and the echo sounder is today a standard piece of maritime equipment. It was soon noticed that reflection could be obtained from shoals of fish, and the use of the echo sounder for fish detection is now well established.

When it is a matter of searching for a single object, the field of investigation can be scanned by a directional beam of pulsed vibrations. This, of course, was originally applied to the location of underwater craft, and it has recently been extended to the location of whales. Although a substantially more difficult problem than the location of submarines, installations on whale catchers are now beyond the experimental stage.

For generation of the pulses the condenser-discharge method of energising a magnetostrictive transducer has obvious attractions. Apart from its simplicity and compactness, it has the advantages of being suited to chart recording with automatic timing, and of being driven by direct current (few ships are fitted with A.C.). The frequency used may be as low as 12 kc/s.—well down into the sonic range—but the short duration of each pulse makes the sound relatively imperceptible.

All the above applications are for use in water. Guides for the blind, using ultrasonic echoes in air, have been developed, but their practical value is perhaps rather doubtful. It is, of course, well known that bats use pulsed ultrasonic vibrations for their navigation.

Flaw detection and thickness measurement

Reflection at phase boundaries makes it possible to detect flaws in objects of all kinds. There are four ways in which the detection may be done:

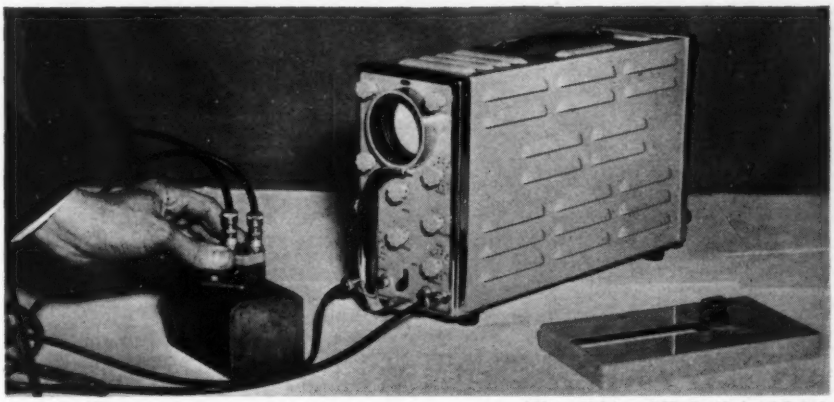
(i) By setting up standing waves in the thickness of the material; the presence of a flaw will interfere with the wave system.

(ii) By detecting the radiation reflected by a flaw, in a manner analogous to echo sounding. Since the discrimination improves with decreasing wavelength, it is usual to work with a crystal generator of frequency 1 to 10 mc.; the radiation is not pulsed, and location is effected by moving transmitter and receiver in vertical or horizontal relation, or by frequency alteration. This is by far the most important of the four methods.

(iii) By detecting the reduction in transmitted radiation caused by a flaw; this requires access to both sides of the specimen.

(iv) The last method may be extended to the obtaining of a true picture of the flaw, using transmitted radiation. A lens is used to focus the radiation on an image converter; this consists of a flat vertical cell with the back wall of aluminium and the front wall of glass. It is filled with a suspension of fine aluminium flakes in xylene. The flakes tend to orient themselves parallel to the ultrasonic wavefronts, and thus to give an image of varying reflectivity to light incident through the glass wall. Such an 'acoustograph' is a true shadow-picture of the flaw. Image converters of this type are extremely sensitive, and are of fine grain and good gradation and contrast; there is no reason why the technique should not be developed using reflected radiation to increase the amount of information obtainable.

The standing-wave method mentioned above is suited to the measurement of the thickness of any object which is accessible from one side only. It differs from echo sounding in that the distance is not inferred from the timing of pulses, but a continuous wave-train is used and the vibrations in the solid brought into resonance by varying the frequency. The most elegant way is to drive a variable condenser mechanically and sweep the anode current of the generator on an oscillograph. The position of the resonance peak corresponds to the thickness, and the screen may in fact be calibrated directly in thickness (for a given material). A quartz crystal is used, applied to the object *via* an oil film, and driven,



[Photo: Kelvin and Hughes (Industrial) Ltd.

Ultrasonic flaw detector designed specifically for testing pressure vessels.

necessarily in forced vibration, in the range 1 to 10 mc/s.

Signalling

A continuous ultrasonic wave, like an electromagnetic wave, can be modulated in amplitude to carry speech. The technique is of practical interest only as regards communication with submarines. In all other cases wireless communication is to be preferred.

A most ingenious extension of the idea is what may be called the 'photoelephone.' In this instrument an ultrasonic carrier wave is modulated with speech, and is then used to set up standing waves in a column of liquid through which a beam of light is passed. Such a standing-wave system, of appropriate frequency, will act as a diffraction grating, and so the modulation of the standing-wave system will be reproduced as an amplitude modulation of the zero-order light. The practicability of the idea is shown by the fact that a range of 3 km. has been achieved in daylight using a 6-v. bulb as light source, with an input to the 7-mc/s. quartz crystal used of only 0.7 w. It is a pity that further development is most unlikely.

Storage circuits

Since the velocity of ultrasonic waves is so small compared with that of electrical impulses, the latter can be 'stored' by converting them, by modulation or as pulses, into ultrasonic waves traversing a mercury column or a block of quartz. Reconversion into electrical impulses after, say, 1 millisecond affords ample delay as compared with impulses retained electrically. The principal uses are in electronic computing and as a timing base in radar.

Viscometry

The problem of measuring continuously the viscosity of a fluid in a closed system is one of great difficulty. The recent development of the ultrasonic viscometer appears to offer a satisfactory solution.

A piezoelectric crystal cut so as to oscillate torsionally, or, more robustly, a metal tongue projecting from the vibrating face of a magnetostrictive transducer, transmits shear waves into the surrounding medium which are damped within a distance of much less than 1 mm. from the surface. The degree of damping, which is conveniently determined by connecting the unit into an a.c. bridge, is proportional, at constant pressure, to the product of density and absolute viscosity. The instrument does not, of course, overcome the two difficulties inherent in all measurement of viscosity: the need for close temperature control or compensation, and the difficulty of interpreting the value obtained with non-Newtonian liquids. But, otherwise, if certain difficulties of installation and design can be overcome, the instrument would appear to be sufficiently simple, and not too fragile, for routine industrial use.

OPERATIVE APPLICATIONS

Operative applications may be classified, according to that property of the vibrations which is used, as dispersive and flocculative. In some cases we are uncertain of the mechanism; most chemical effects are probably dispersive, and these shade off into the biological effects, where a combination of causes may be active.

DISPERSIVE

Emulsification

This is likely to become one of the most important applications of ultrasonics, but there has been—and indeed is still—a considerable amount of confusion about the mechanism. Early work was done with crystals working at 150 kc/s. or over, where emulsification arises apparently by the violent projection of one phase into the other, in a way akin to the projection of liquid as a spray into the air, the 'ultrasonic fountain.' It was later found that magnetostrictive transducers, working below 35 kc/s., would give good emulsions provided that the phase boundary was near the vibrating face. This is not a projection effect and is almost certainly due to cavitation. Cavitation is the successive formation and collapse of cavities or bubbles in the liquid by its tearing apart in zones of negative pressure, especially at phase boundaries. Very large localised forces are developed, which are quite large enough to account for the observed increase of interfacial area. Emulsification at low frequencies is in fact more efficient than at high, in accordance with theory, for at piezoelectric frequencies the cavities literally have not got time to form. But high-frequency emulsification, especially of mercury and molten metals, is a real and distinct phenomenon, as is shown by the fact that it proceeds under vacuum or at pressures too high to permit cavitation to occur.

How attractive these methods are in comparison with orthodox emulsification methods is uncertain, but they are not likely to achieve any great importance unless their energetic efficiency can be considerably increased. They are being displaced, even before they have become established, by liquid whistles, which seem likely to become of considerable industrial importance.

It is generally agreed that ultrasonically-produced emulsions are characterised by small particle size and narrow size-range, but much of the published work is of less value than it might be, from lack of remembering that the physical chemistry of ordinary emulsions must still be taken into consideration. We shall see that ultrasonic waves possess a flocculative as well as a dispersive effect, and the result of this is that on prolonged irradiation a dynamic equilibrium is set up, so that high disperse phase concentrations may not be achievable. The effect of an emulsifying agent on such a system depends on whether it aids emulsification or merely stabilises the emulsion produced. If the former, then it may have no more than a minor effect on the concentration attainable, for it will tend to aid coagulation as well; if the latter, then it will cause an increase in the concentration attainable.

Solid wetting and dispersion

Ultrasonic vibrations can erode metal surfaces to give dispersions; the effect is presumably a cavitation erosion similar to that observed on, *e.g.*, ships' screws. This simple process is not attractive. If, however, during electrolytic deposition, the cathode is vibrated ultrasonically, the metal becomes dispersed as it is deposited, enabling dispersions of high concentration to be obtained in good yield. The technique would appear to have possibilities.

Good results have been claimed for the use of ultrasonic vibrations in the preparation of photographic emulsions, to improve homogeneity and reduce the size of the silver halide particles. It is not easy to assess the value of this highly-specialised application.

The dispersion in liquids of a variety of non-metallic materials has been described in the literature, but the possible industrial importance of much of the work is very uncertain. One field of real importance is that of the paint industry, where the problem essentially is to wet with a liquid hydrocarbon aggregates of hydrophilic pigment whose ultimate particle size is already of the right magnitude. Existing methods are energetically inefficient or involve high capitalisation, and there is undoubted scope—if not an active demand—for a better technique. Although piezoelectric generators have been used, it would seem that the problem is more efficiently tackled as one of cavitation, using magnetostriction at 30 kc/s. or below. The successful solution depends on the realisations, firstly, that a continuous process is essential and, secondly, that the problem is one of wetting with the appropriate liquid, leaving the dispersion of the wetted material—a relatively simple matter—to be dealt with subsequently and separately. The energetic efficiency of such a process compares favourably with that of any existing technique, and it offers secondary advantages which may in practice prove more important than the wetting process itself. The main difficulties, which have not yet been solved, are the design of the dispersion cell and the handling of the materials. It is worth noting that the success of such a development might alter the whole pattern of the paint industry, for the logical procedure would be for the pigment maker to carry out the wetting of his pigments in bulk, leaving to the paint maker merely the simple process of dispersion.

Laundering

Considerable publicity has been given to the ultrasonic washing machine, using magnetostrictive generators reaching down

into the sonic range. Considered as an aspect of solid wetting and dispersion, the idea would seem technically sound; it is known that textile fibres can be cleansed in this way, but also that different kinds of dirt differ widely in their ease of removal. The practical attractiveness of the method is less certain; while not doubting the claims made, it is difficult to see how the vibrations can permeate a large volume of water in presence of so much material of high acoustic absorption, and it is at least possible that the effects can be ascribed to agitation by water currents arising as a secondary effect. Recent advances in design of conventional washing machines show what good results can be obtained by this type of agitation, and it is permissible to doubt if an ultrasonic transducer is the best way of achieving it.

Soldering

The soldering of aluminium by conventional methods is not at all easy, owing to the rapid formation and tenacity of its oxide film. This film can be disrupted ultrasonically, and the soldering of aluminium is made quite easy by the use of a soldering iron whose head is vibrated by a magnetostrictive transducer.

Drilling

Holes of any cross section may be drilled in the hardest material by using, in presence of a slurry of abrasive powder, an appropriately-shaped head which is vibrated ultrasonically, preferably by being bonded to the face of a magnetostrictive transducer. Carborundum serves as abrasive for most purposes, but for diamond drilling, diamond powder is, of course, needed. Since the action is that of a reciprocating pick and not of a rotary drill, there is no limitation on the cross-sectional shape and, since the driving bond may be flexible, the hole may be drilled in a curve. The cleanness of contour is good and the speed of drilling surprisingly fast.

At the moment the idea is being developed principally for drilling diamond dies and the like, but it clearly has great potentialities in the working of all hard brittle materials. The technique has definite possibilities from the purely decorative aspect.

FLOCCULATIVE

The general tendency of standing-wave systems to cause segregation of particles of foreign matter present in the medium is well shown by 'dust figure' demonstrations in general and by the Kundt's tube experiment in particular. Analysis of the problem shows that besides inertial forces, which tend to cause the particles, as they swing with the wave, to migrate to the nodes, radiation pressure tends to drive the particles to the loops; the latter effect predominates as the size of the particles falls and is the more important in aerosol systems. There is no need to postulate any but the ordinary collision mechanism for the actual coagulation, and the vibrations influence this in three ways.

(i) The increase of relative particle velocities leads to a greater chance of effective impact.

(ii) The increase of relative particle velocities leads to a greater number of collisions.

(iii) The segregation of particles at nodes and loops leads to an increased concentration and thus to a greater number of collisions.

It may be noted that the first two effects occur before the equilibrium position is reached and refer to particles of differing mass, while the last effect will be important after equilibrium is reached and between particles of the same size.

[Photo: Ultrasonics Ltd.

Ultrasonic emulsifier, which is portable and can be clamped on to mixing vessels. Below is a section through the emulsifying head.

Dedusting of gases

The application of the above to the dedusting of gases, a problem which has not otherwise been solved satisfactorily, is obvious. The siren is the generator of choice, since it generates directly in air at high efficiency and can be made in very large units; its accompanying air flow is no disadvantage. For several reasons the main development has been in the U.S.A., where a number of installations exist and are extremely effective. Ultrasonic dedusting has the advantages over electrostatic precipitation of lower capital cost and greater simplicity, and over the Venturi scrubber of recovering the product dry; it is clearly going to be of great importance in the recovery of valuable products from gaseous suspension. For effluent gas treatment its competitive status is less certain, as it suffers from one great disadvantage which may often be decisive against it. In order to give standing-wave systems of dimensions commensurate with the dimensions required for low pressure drop and adequate delay time, the frequency used has to be low, often well down into the sonic range. At 3.5 kc/s., a frequency actually in use on the large scale, the wavelength in air is still only about 10 cm., but how many half-wavelengths can be included in a stable standing-wave system under these conditions is not known.

Atmospheric fog may be coagulated by this method, but the disadvantages are obvious, quite apart from the physiological risk.

Coagulation in liquids

Suspensions in liquids can be flocculated in a standing-wave system in exactly the same way as suspensions in gases. We have already seen that the effect may be a nuisance when emulsification is being effected. Although the principle is the same in each case, the practical applications are rather sharply distinct according as the particles concerned are ordinary suspended particles, nuclei for bubble growth, or nuclei for crystal growth.

Flocculation

Flocculation of suspended matter may readily be achieved, but has not yet attained any substantial importance. There is clearly a large number of occasions, especially in effluent treatment, where conventional flocculation methods are unattractive. Low frequencies are to be preferred, obtainable by magnetostriction or by the liquid whistle.

Degassing

The evolution of dissolved gases in bubbles from ultrasonically-irradiated liquids is well known. Aggregation of nuclei seems to be the usual initiative cause, but cavitation will play a part under conditions of high intensity. Whatever the cause, the effect is of great potential importance in metallurgy, glass technology and the food industry. The practical difficulties, especially in the first two industries, are considerable, and do not appear to be near solution.

Scale prevention

The scaling of boilers can be effectively prevented by irradiation of the heating surfaces with low-frequency (magnetostrictive) ultrasonic waves. The effect is remarkable for the very low power required—less than 100 w. electrical input for all but the largest boilers; the radiation is conveniently supplied as pulses from a condenser-discharge generator. It is of interest that existing scale incrustations are also slowly dislodged. Because of its cheapness and simplicity the method is extremely attractive economically, in particular for low-pressure fire-tube boilers. Even in cases where the operating pressure is high enough to demand chemical feed water treatment, there seems to be an economic advantage in installing ultrasonic descaling.

The mechanism is not wholly clear; it involves deposition of the scale material as a soft sludge instead of a compact adhering film. This may arise by flocculation of the crystals as they form, or may involve initiation of crystallisation by aggregation

of nuclei. There is no reason why the technique should not be extended to other cases of crystallisation and precipitation.

Grain refining of metals

Ultrasonic irradiation of a solidifying metallic melt can result in a substantial change in the crystal texture, notably in the direction of improved fineness and homogeneity. The result is frequently a substantial improvement in mechanical properties. The phenomenon is usually treated as a dispersion effect, but it would seem to be more reasonably regarded as an initiation of crystal growth at a greatly increased number of centres caused by aggregation of nuclei. There is evidence supporting the first explanation, however, and it is not unlikely that both effects occur simultaneously. The practical development of the process, which is of considerable potential value, depends upon solving the two problems, inherent in metallurgical operation, of working at high temperatures and with a large mass of material.

CHEMICAL EFFECTS

The large amount of published work is not easily summarised without cataloguing, but the results, which have mostly been obtained using piezoelectric vibrations, may be broadly grouped as follows:

(i) Solutions of high-molecular-weight materials are considerably changed in properties such as viscosity. The effect is reversible and is not a degradation, but a disruption of the gel or micelle structure by some method such as removal of sheaths of solvent molecules held by van der Waals forces.

(ii) True degradation of materials such as proteins, polysaccharides and synthetic polymers is also obtainable. In these cases the energy available can be shown to be adequate for the rupture of C—C bonds.

(iii) A number of reactions is accelerated. They fall into three typical classes: those in which gases are evolved, those in which the reactants are not far from immiscibility, and chain reactions such as certain polymerisations.

(iv) Where dissolved oxygen is present there is formation of hydrogen peroxide or an oxidising agent of similar behaviour. A large number of effects is explicable on the basis of secondary reaction with this material.

(v) Luminescence effects are common.

(vi) The considerable electrochemical changes observed all seem to be referable to alteration of the electrode surfaces in ways which are already known.

It is clear from the above that ultrasonic vibrations can activate molecules to a certain degree, and the luminescence effects suggest that types of activation otherwise unattainable are possible. But there is no case of ultrasonic irradiation making a reaction occur which otherwise would not, although this possibility cannot be excluded. All the evidence suggests that the efficiency is very low, and ultrasonic irradiation does not seem to have any attractions in the chemical field.

BIOLOGICAL EFFECTS

Ultrasonic vibrations may cause dispersion, flocculation, cavitation, degradation of large molecules, formation of hydrogen peroxide, high and rapidly-changing pressures and, inevitably, the evolution of heat. It is therefore not surprising that living organisms are affected.

We may dismiss the curative aspect by noting that ultrasonic vibrations of various frequencies have been claimed to cure or alleviate at least 20 complaints, ranging from deafness to cancer, but that the ultrasonic generator cannot in spite of this be said to be a common piece of medical equipment.

The deleterious effects of ultrasonic vibrations on a wide variety of living organisms are well established, and they have frequently been suggested for pest control. For such a use their status must be assessed in the same way as a chemical pest control agent. The fundamental requirement is that a proposed agent should either be able to do something previously impossible or be able to replace an existing material on grounds of economy or convenience. The detailed requirements are that it should be effective, easy to apply, non-injurious to man and economic animals, not leave any dangerous or objectionable residue and be unlikely to cause the development of resistant strains.

The particular merit of ultrasonic waves is that they leave no residue. This immediately suggests their use for disinfecting or disinfesting foodstuffs such as milk or stored grain.

Moderate technical success has attended attempts to sterilise milk ultrasonically. It is still difficult to achieve the very high percentage kill required with such rapidly-multiplying organisms as bacteria, and a fluid such as milk is clearly susceptible to a variety of ultrasonic effects. Nevertheless, the problem deserves further work being done on it. Unfortunately, the economics are complex; they involve the question of loss suffered by the consumer rather than the supplier, and that of the value placed by the consumer on the gastronomic superiority of fresh over pasteurised or conventionally-sterilised milk.

The control of insect pests in stored grain is much more difficult technically, since large volumes of highly damping material are involved, and it is doubtful if disinfestation can be achieved except at relatively enormous expense. This is a subject which should not be worked on further, since it is now realised that good housekeeping is the best and cheapest solution; deliberate disinfestation should be regarded as an emergency measure.

As the two above examples show, each application needs individual consideration. It is not possible to say that ultrasonic pest control has great potentialities; it is possible to say only that ultrasonic waves may prove attractive in a certain combination of circumstances. No ultrasonic pest control application has as yet been commercialised.

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CELLULOSE ACETATE

(*Concluded from page 9*)

has passed through the length of the extruder it is converted to a hot, highly viscous and homogenous (or colloided) mass. The material leaves the extruder through a die designed to form the material into rods. The number of rods from a machine is roughly related to the output capacity. For example, a machine of about 300 lb./hr. capacity runs at 18 rods.

Cooling, chipping and packaging

The material converted to colloided strands now requires to be cooled, reduced to the desired diameter ($\frac{1}{8}$ in.) and cut to the desired length ($\frac{1}{8}$ in.). Cooling is effected by passing the rods first through a water bath, then along a conveyor belt where they are further cooled (and dried) by an air blast. Milled rollers then draw the strands into the chipper. By regulating the speed of these rollers in relation to the extruder output, the diameter of the rods is controlled.

The operation of the chipper is similar to that of a chaff cutter, namely a fixed anvil over which the rods pass, followed by rotating blades which shear off the rods in the form of pellets. By this method of chipping, fines are kept to a reasonably low figure. By gearing the feed rolls to the cutting blades, pellet length is maintained constant for all speeds of the cutter.

The pellets leaving the chipper are run direct to packaging. Packages generally used are fibre-board cartons of cylindrical shape holding 112 lb., or multi-wall paper packages holding 56 lb.

Pernis is now Europe's Biggest Oil Refinery

THE new 3½-million-tons-p.a. distillation unit for the Pernis (Rotterdam) oil refinery of the Royal Dutch/Shell Group has now come on stream, and with this additional capacity the refinery becomes the largest in Europe (including the U.K.) with an annual crude capacity of nearly 10 million tons. Built at a cost of £2 million, the new unit, designed by Shell, has taken just over a year to erect.

Before the war, Pernis refinery had a capacity of only 1 million tons of oil products a year. It suffered heavy damage during the war, but rehabilitation was started in 1946. Since that time, the size has gradually been increased until it is now the most comprehensive refining complex in continental Europe.

This has been done at a cost of over £25 million, and the refinery, in addition to four distillation units, now includes such facilities as thermal cracking and reforming units, a catalytic cracking unit, polymerisation plants, lubricating oil and bitumen plants and treating facilities to which a luboil de-asphalting and extraction plant, now under construction, will be added.

Chemical plants. There is also a plant for making synthetic detergents, one for the manufacture of base materials for plastics on a polyvinyl chloride basis and another for making epikote resins, used as a very resistant compound in the paint and varnish industry. Also, sulphur is recovered on a large scale. A plant for the production of a number of chemical solvents is under construction as well as a plant for the manufacture of the new insecticides dieldrin and aldrin.

Processes. For the primary treatment of crude oil, the refinery possesses four distillation units with a total daily capacity of 25,000 tons; the products obtained in them (the so-called straight-run products) are: light and heavy gasoline, kerosine, light and heavy gas oil, and residue. Moreover, propane and butane are separated from the gases.

The further treatment of the residue takes place in two different ways. According to the first method, the residue serves as a base material for two of the four high-vacuum distillation units, waxy distillates being obtained and a new heavy residue left. This residue can be admixed to fuel oil or be delivered as asphalt after further treatment. The waxy distillates obtained from the high-vacuum distillation serve as a base feed material for the catalytic cracking plant. Other waxy distillates are dewaxed in a special plant by dilution with a solvent, consisting of a mixture of methyl-ethyl-ketone and benzene, following by cooling with liquid propane. The wax obtained in the dewaxing process is cracked in the vapour phase in a thermal cracking plant specially designed for this purpose.

The second method for the treatment of the residue obtained in the crude oil distillation is the cracking process, which is applied in a two-stage thermal cracking plant with a total capacity of 3,000 tons daily. In one stage, residue or heavy crude oils (which can also be used as base material) are converted to a large extent at high temperature and pressure into cracked gasoline and gases, a liquid cracked residue being formed. In the other stage, cracking conditions are such as to yield coke as a residue. This cracking to coke gives the highest possible gasoline yield.

Another application of thermal cracking is found in the reforming plant, a unit with a daily capacity of 1,200 tons, in which gasoline fractions with a low octane number are converted into higher-grade products.

The latest addition to the equipment is the catalytic cracking plant. At the rate of 3,900 tons daily, a base material consisting of heavy distillates is cracked in the vapour phase in this plant with the aid of a catalyst (a combination of aluminium and silicium oxides), gasoline of a high octane number being produced.

The gases formed in the various cracking processes are further treated in two gas plants, where butane-butene and propane-propene are separated from the lightest gases.

Finally, the refinery includes a number of purifying plants for gasolines and for kerosine, as well as a redistilling plant for the manufacture of special-boiling-point gasolines.

Smokeless Fuel Processes

We regret that errors occurred in three of the captions to this article which appeared in our November issue.

Fig. 4 shows a group of *carbonising* chambers at Carmaux.

Fig. 6. The key to the diagram is as follows: (1) Briquette bin with gas-tight feeder for charging. (2) Pre-heater for briquettes. (3) Circulator for pre-heating gas. (4) Heat exchanger for heating the pre-heating gas by means of warm gas produced. (5) Shaft for coking. (6) Electric furnace for heating the coke briquettes. (7) Cooling of coke briquettes by cold circulating gas. (8) Arrangement for regulation of speed of downward travel of briquettes and gas-tight discharge of same. (9) Cottrell tar unit. (10) Gas cooler and steam injection unit. (11) Circulator for coke gas. (12) Annular flue for discharge of hot gas. (13) Upper electrodes (three-phase). (14) Lower electrodes (three-phase).

Fig. 7. Again this refers to a *carbonising* plant and not a briquetting plant.

Research on Chemical Reactions at the Royal College of Science

Research on catalysis, gas reactions and reactions in solution, and on hydrogen-transfer reactions is among the work being done at the Royal College of Science (Imperial College, London). Here is an account of these investigations taken from the Research Report of the Royal College of Science, 1950-52, published recently.

Adsorption and surface reactions

DESPITE abundant literature on the subject, the choice and preparation of catalysts remains an art rather than a science. Hence, when a fundamental investigation of metal hydrogenation catalysts was undertaken in the Department of Inorganic and Physical Chemistry, it was essential to choose the simplest catalytic reaction, the splitting of the hydrogen molecule (H_2) into its constituent atoms (H) at the surface of a clean metal film. Calorimetric studies have been made to measure the energy liberated when the hydrogen molecule forms a surface complex with the metal. The factors controlling the rate of this simple process have now been elucidated. In technological practice, oxide impurities are added to promote or increase the efficiency of the catalyst, and this aspect has also been investigated. The factors affecting the useful life of hydrogenation catalysts, which can be poisoned, have been deduced from the effects of other gases normally present in industrial processes, *e.g.* oxygen, nitrogen and carbon monoxide.

Allied to this problem is one concerned with the nature and cause of hair-line cracks in metals, undoubtedly produced by absorption and desorption of hydrogen during extraction and casting. Investigation of the diffusion of hydrogen into pure iron at high temperatures is being furthered in order to throw light on this problem. By pretreatment with carbon monoxide the rate of absorption of hydrogen is greatly reduced and this discovery may lead to a method for the elimination of hair-line cracks, thus increasing the tensile strength of the metal. Economically these defects represent a costly and troublesome factor, and an understanding of their formation, leading possibly to a means of prevention, would be a great advance.

Kinetics of gas reactions and reactions in solution

A series of researches into the combustion of simple derivatives of the paraffin hydrocarbons has been continued in the Department of Inorganic and Physical Chemistry in an attempt to elucidate further the structural factors which control the ease of oxidation of organic molecules. In particular, the vapour-phase oxidation of secondary and tertiary amines has been studied. Studies have also been made of the vapour-phase decomposition of some simple aromatic compounds. Benzene derivatives containing only a monatomic substitute, *e.g.* chlorobenzene, have been examined; decomposition of these compounds must involve fission of carbon-carbon bonds in the benzene ring or of the bonds joining carbon to hydrogen or other substituent atoms.

Organic compounds similar to the hydrocarbons, but with hydrogen replaced by fluorine, have properties notably different from those of the hydrocarbons. A very large amount of energy is required to break bonds between carbon and fluorine atoms, and therefore some fluorocarbons have a high resistance to heat. As part of a programme of work designed to give quantitative data on the properties of fluorocarbons, the thermal decomposition of tetrafluoroethylene has been studied. When tetrafluoroethylene is heated, pairs of molecules combine to give the dimer, octafluoro*cyclo*butane and, at temperatures about 500°C., octafluoro*cyclo*butane dissociates back to tetrafluoroethylene, both quite remarkable reactions. From the rates of these reactions, the heat of reaction for the dimerisation has been determined. At higher temperatures other fluorocarbons are formed, and the work has included determination of some physical properties of these compounds. An unusual feature in the technique for the kinetic studies is that at high temperatures an oxide-free metal reaction vessel must be used, as fluorocarbons react with both silica and metal oxides in those circumstances.

With regard to reactions in solution, a study is in progress of the oxidation of alkyl side-chains in aromatic compounds by potassium permanganate in acid solution. The most detailed investigation has been carried out with toluene, but substituted toluenes and the higher homologues of toluene are also being examined. An investigation into the iodination of aliphatic ketones has been continued.

Hydrogen-transfer reactions

A well-known synthetic method for the reduction of organic compounds, which is employed, for example, in the large-scale conversion of vegetable oils and fish oils into margarine, consists of the addition of gaseous hydrogen by means of metallic catalysis, such as palladium, platinum or nickel. A possible alternative, which is of great theoretical as well as practical interest, involves the transfer of chemically-bound hydrogen from one organic compound to another in the presence of similar catalysts. An investigation based on this conception has been started in the Department of Organic Chemistry during the last three years and has disclosed that metal-catalysed transfer of hydrogen from one compound to another can indeed be realised and put to practical use by a judicious choice of hydrogen-donors. One of the most effective donors, cyclohexene, is a commercially available material and has been found to be, in combination with palladium, a more convenient and selective reducing agent for a wide range of hydrogen-acceptors than gaseous hydrogen or other conventional reducing agents. Each combination of metal and hydrogen-donor is effective in reducing only certain specific chemical structures. All these reactions are very sensitive to inhibitors. This behaviour is paralleled only by that observed in natural enzyme reactions, to which the transfer reactions bear other points of resemblance, in that, for instance, they take place at the surface of a solid in contact with a liquid. Very few systems of this type have previously been investigated, no doubt owing to the experimental difficulties involved. A technique ensuring reproducible surface conditions, and allowing quantitative study of the reactions, has now been evolved.

Heat Transfer

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SOUTH AFRICAN URANIUM

By W. Williams

The need for uranium to fuel the Atomic Age has created a new industry in South Africa. The discovery of economically recoverable quantities of uranium in gold mine residues was quickly followed by the development of an extraction process and by the end of this year 22 mines will be producing uranium. Eventually it is expected that uranium will bring the country more than £30 million p.a. The rapid development of the industry has been achieved by close collaboration between British, American and South African chemists and engineers. In this article the author describes the birth and growth of the industry and gives technical details so far as security restrictions have permitted.

WHEN the strategic importance of uranium-bearing minerals was first realised, a wide search was conducted throughout the Union of South Africa. Traces were detected in many widely-separated localities, but the deposits were not of such a nature as to warrant commercial exploitation.

Later, attention was turned to the gold mines. The presence of uraninite in the Witwatersrand gold ores had been detected in 1923, although at that time it was of purely academic interest. In 1945, Geiger counter tests were carried out on South African gold ores and strong positive reactions were obtained. Subsequently a joint British-American team visited South Africa to conduct a full investigation of the uranium content of gold ores and proved there was more available than had been thought hitherto. A Uranium Research Committee was then set up which organised the analysis of over 40,000 samples of ore during this period. The committee was the forerunner of the Atomic Energy Board which was established in 1949 to organise full-scale production. Apart from ore analysis, research was also carried out on the flotation and gravity methods necessary to produce concentrated material suitable for leaching and final uranium recovery. After two years a practical and economic process was evolved.

During this period, collaboration took place between scientists at the Massachusetts Institute of Technology, the Chemical Research Laboratories at Teddington, England, and the Government Metallurgical Laboratories in Johannesburg.

Pilot-plant work

The way was now open for pilot-plant production tests. At this stage the gold mining industry itself began to help. The first pilot plant was a small one built with Government funds at the Johannesburg Metallurgical Laboratories. This enabled the economics of the process to be evaluated.

Larger pilot plants were next set up to test the necessary mechanical equipment which would be needed for uranium production on a large scale. The first of these pilot plants was completed in October 1949 at Blyvooruitzicht Gold Mining Co. Ltd. Next followed similar plants at Western Reefs Exploration & Development Co. Ltd. and Sub-Nigel Ltd. The latter plant was subsequently used on three other mines for testing.

While this progress was achieved, other tests proved that payable quantities of uranium could be recovered from other gold mines which were no longer able to produce gold on a profitable basis owing to high working costs and low payability of the ores. An example of this type was the Bird Reef series of the West Rand Consolidated Mines Ltd. Altogether 34,000 samples of the Bird Reef conglomerates were taken between June 1949 and January 1951. At the same time, assays of borehole samples on the new developing mines in the Orange Free State and the far west Rand again indicated that the uranium content might add considerably to the potential uranium production of South Africa.

International agreement

By now the stage was set for production of uranium to be organised on a large scale. Accordingly, the South African Atomic Energy Board entered into an agreement with the governments of the U.S. and the U.K. on November 23, 1950. This authorised uranium production by West Rand Consolidated Mines Ltd., Daggafontein Mines Ltd., Blyvooruitzicht Gold Mining Co. Ltd. and Western Reefs Exploration & Development Co. Ltd. Soon afterwards, West Driefontein Gold Mining Co. Ltd. and Stilfontein Gold Mining Co. Ltd. were added to the list of authorised producers. In December 1951, supplementary agreements were entered into providing for further expansion of the uranium industry, and now there are 22 mines authorised to proceed with uranium production; others are under consideration.

Control of uranium industry

The necessary funds to finance these elaborate undertakings were made available from British and American sources. The loans will be repaid from uranium sales to the U.S.A. and Britain. South Africa's Atomic Energy Act of 1948 gave extensive powers to the State, which controls the sole right to prospect for, mine and process uranium. The Minister of Mines is chairman of the controlling Atomic Energy Board, which is responsible for the production and disposal of uranium. In turn, the board has made agreements with the individual gold mines whereby the mining industry itself has undertaken the actual production of uranium while the board disposes of the product and passes on to the mining companies payment in accordance with the agreements. Elaborate security measures were laid down for the plants, and information such as ore reserves, production figures, research work and certain technical data on the processes used may not be disclosed.

Production stage reached

Once the various agreements had been signed, the detailed planning of the large plants, ordering of the equipment and then construction work went ahead rapidly. A Technical Sub-Committee of the Gold Producers' Committee was responsible for the design of the plans and supply of the necessary raw materials. Very high priority was placed on the whole project by the various governments concerned, so that large tonnages of the necessary steel and other essential materials and machinery were delivered at very short notice.

South African manufacturers and engineers rose nobly to meet the urgent demands of the new industry, and much of the actual fabrication of equipment was carried out in South Africa. Many techniques were used for the first time on a large scale in the Union. The lining of various parts of the plants with rubber to resist acid corrosion is probably the largest job of its kind every undertaken anywhere in the world.

While planning the various mining and processing steps for the uranium ores, great attention was given to the health of the personnel. Elaborate tests were made, including underground observations at various mines to prove that there was no radon gas present and that dust in the air did not contain signs of radioactivity of a dangerous level.

Erection of the first plants proceeded rapidly and by October 1952 the first plant, that of the West Rand Consolidated Mines, had reached production stage. At least two other mines are now producing and others are well advanced in construction.

It is expected that all the 22 mines will be in production by 1955.

The extraction process

After the gold has been extracted from the finely crushed ores by conventional methods, the residues are conveyed to the uranium plant. In this connection it is of note that the vast slimes dumps of spent gold ores also provide a reservoir of uranium-bearing material which can be utilised to augment new supplies of gold residues. On reaching the uranium plant, the ores are first treated with dilute sulphuric acid, of which very large quantities are required. The acid dissolves the uranium and the solid residues are filtered off in large rotary filters and afterwards discharged to slimes dams in the usual manner.

The solution obtained by acid digestion contains many substances besides uranium and has to be subjected to further processes before a pure uranium solution is obtained. From the pure solution the uranium is precipitated and leaves the plant in the form of a bright yellow mud. It is then sent to a central plant where it is converted by calcining into a dry uranium oxide, uranyl uranate, U_3O_8. The oxide is still not sufficiently pure for use in the atomic energy programmes and, after export to Britain and the U.S.A., it is further refined. If used as feed for an atomic pile, the oxide is reduced to its metallic state. If used for separation of the isotope U.235 it is turned into the gas, uranium fluoride.

Sulphuric acid manufacture

The very large demand for sulphuric acid used in the uranium extraction process has led to the creation of a complete industry for acid manufacture in the neighbourhood of the gold mines. Raw material in the form of pyrites is readily available from waste mining ores. One small acid plant is already producing on the West Rand and three large plants are being erected to serve the various Reef mines as they come into the producing stage. A further large plant is planned for the Orange Free State goldfields area to supply the mines in that area (already seven mines are authorised uranium producers) which are now reaching the production stage for both gold and uranium. The new acid plants will make the Union independent of overseas supplies and eventually a valuable export trade may be built up.

Power for uranium projects

The additional electric power necessary for running the uranium extraction plants on the Witwatersrand will be supplied by the greater part of a £10-million power station with a capacity of 180,000 kw. which is being erected by the Electricity Supply Commission (Escom), at Wilge, near Kendal, in the Transvaal.

This power station will actually augment the supply of current to Escom's Rand undertaking from which electricity will, in turn, be drawn for uranium production. The Rand undertaking is being further expanded by a £20-million power station at Taaibos and another costing £15 million at Vierfontein. The latter two will augment the general supply, but the one at Wilge was originally intended to be much smaller and was enlarged solely to meet the additional requirements of uranium production.

A loan of about £7 million for the work at the Wilge power station was granted to the Commission by the Import-Export Bank in Washington during July 1952.

Uranium and the S. African economy

In developing its uranium industry, South Africa was fortunate in having the backing of the wealthy and substantial gold-mining industry from the start. Standing in such close relation to this established older industry, the production of uranium was immediately placed on a sound footing and could be undertaken on a profitable large-scale basis. This fact also simplified the initial work. It made the additional organisation easy, so that within a comparatively short time after the first official announcement it was possible to begin production.

The importance of uranium to South African economy is shown by the recent statement of the Prime Minister that uranium sales will bring at least £30 million p.a. into the country when there is full production. In addition, the gold-mining industry has been stimulated and some mines have been given a new lease of life.

Who's Who in British Science

LEONARD HILL'S NEW REFERENCE WORK

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The compilers have thrown their net wide to include scientists and technologists in such diverse fields as Chemistry and Zoology, Physics and Biology, Engineering and Agriculture, Medicine and Botany, Microbiology and Meteorology, Nutrition and Entomology, Geology and Mathematics, Genetics and the Social Sciences. There are more than 3,000 entries giving personal and professional particulars of most of the leading British scientists in industry, research and the universities; many of them with world reputations. These particulars include Christian names, date of birth, civil and academic distinctions, present appointment or status, professional and private addresses, education and professional training, official position in learned societies, previous positions held, special subjects, books published, and clubs.

Comprising 300 pages, the book contains a vast quantity of information nowhere else available in such a convenient form. It will undoubtedly become a reference work indispensable for all who are in any way connected with scientists and their work.

Who's Who in British Science, 1953 is published by Leonard Hill Ltd., Stratford House, 9 Eden Street, London, N.W.1. Price 42s.

Contributions and Correspondence

THE EDITOR *welcomes practical articles and notes on chemical engineering and industrial chemical subjects with a view to publication. All contributions, which should be fully illustrated whenever possible, are carefully considered. A preliminary letter or synopsis is advisable. Address such material to* THE EDITOR, CHEMICAL & PROCESS ENGINEERING, Stratford House, 9 Eden Street, London, N.W.1.

Letters for publication on any of the subjects covered by this Journal are also invited.

P-32 from pile-irradiated sulphur

The production of phosphorus 32 from pile-irradiated sulphur at A.E.R.E., Harwell, by a simple process of extraction and purification is described in a new report by Arrol and Hudswell of the Harwell staff (H.M.S.O., 3s.). The product is in the form of orthophosphate at high specific activity. The principles of the processes are stated. The development and construction of a rocking autoclave for the extraction is described with the aid of diagrams. The all-glass purification apparatus which is designed to treat the phosphate extract is operated entirely behind *Perspex* shielding. The method of operation is described in full detail; it has been found necessary to introduce a step for the elimination of arsenic. The routine inspection of the product for purity and activity is discussed. The possible weekly rate of production by one operator is 7 kg. of sulphur, *i.e.* about 7 to 8 curies of 32P at the present pile flux.

The number of the report is AERE/I/R 1033.

Russian Sulphuric Acid Process

ACID AND SULPHUR FROM PYRITES, ANHYDRITE AND COAL

The following account of what is claimed to be a new Russian method for the production of sulphur and sulphuric acid from gypsum or anhydrite plus pyrites, etc., has been submitted to the technical experts of I.C.I. at Billingham. They consider that the work is preliminary and that the reactions mentioned are basically similar to those described in previous work. The use of oxygen in an air/oxygen mixture for the decomposition of calcium sulphate appears of doubtful utility. Further work on a somewhat larger scale is needed before results of commercial value can be obtained.

Although the Russians generally ignore non-Russian research, it seems unusually strange in this case that the considerable body of European work on this process has not been mentioned. In this country I.C.I. have carried out a lot of work on the production of sulphuric acid from anhydrite and they are giving technical assistance to the new Merseyside anhydrite-acid plant due to be completed this year. In France there is an anhydrite-acid plant at Miramas and in Germany there are two at Wolfen, in the Soviet Zone and at Leverkusen in Western Germany.

In all these plants coal is used with anhydrite (or gypsum), alumina, sand and other ingredients, and the process has the added advantage of yielding cement in addition to acid. One of the chief features of the proposed new Russian method is that pyrites is used as the main constituent, with anhydrite as the secondary one. Carbon and alumina are also used. At present the process does not appear to have got beyond the small pilot stage, though it is said to be of considerable economic importance to Russia and satellite countries. But cement in this case does not appear to be a possible by-product, as it is not mentioned by the author.

THE new method for obtaining elemental sulphur and sulphuric acid from a briquetted mixture of ground pyrites (FeS_2), anhydrite ($CaSO_4$) and coal is said to have been tried on both a laboratory and pilot-plant scale. It is described by S. N. Ganz in *Zhurn. Prikladn. Khim.* (*Jnl. of Appl. Chem.*), 1953, **26**, (5), 464-474.

Pyrites plus coal is called 'carbonated pyrites' and the term gypsum is often used for the calcium sulphate, though it seems that the anhydrous form (anhydrite) is mainly used. The author points out that these materials have hitherto been seldom considered for this purpose, which has great economic importance in Russia and allied republics, as the optimum conditions for same have not been fully understood. He endeavours to establish these on a definite experimental basis. The general and basic idea is that, although gypsum requires considerable heat for its dissociation, yet, if coal-mixed pyrites is burnt with it, sufficient heat is evolved to ensure its dissociation, especially with the aid of a blast of wet air-oxygen mixture.

There are four fundamental types of reaction in the general scheme: (*a*) conversion of FeS_2 into FeS and S; (*b*) FeS plus $CaSO_4$ forms calcium ferrite, calcium sulphide and SO_2 and, in the presence of oxygen, both SO_2 and Fe_2O_3 are formed—also, under the right conditions, CaO and S; (*c*) $CaSO_4$ with C (carbon or coal) form CaS and CO_2 or CO; and (*d*) in another zone with water and CO_2 there are formed $CaCO_3$ and H_2S or, without the CO_2, CaO and H_2S. The oxygen supply should be merely sufficient to maintain exothermic conditions and the required temperature, together with a weakly acid medium. The most likely constituents in the gaseous phase are SO_2, H_2S, CO and H_2, which interact with a lowering of temperature in the upper part of the furnace to form elemental sulphur from the SO_2, plus respectively CO, H_2 and H_2S, together with formation of water or CO_2. Variation of temperature, composition of batch or briquettes, and rate and moisture content of the air-oxygen blast, will determine main content of gases present and sulphur. The author considered his main task to be that of explaining (*a*) effect of temperature distribution in zones, coal and pyrites feed, and oxygen concentration, and extent of $CaSO_4$ dissociation and composition of gases; (*b*) effect of the addition of alumina on such dissociation and on the strength and stability of the briquettes; and (*c*) effect of water vapour on gas composition, on concentration of its constituents and on $CaSO_4$ dissociation.

Experimental

Materials used were ordinary pyrites containing 36.33% sulphur, gypsum (anhydrite) containing, after drying at 160°C., 21.35% sulphate sulphur, and coal with ash content of 17.1% and moisture 8.7%. These were ground, mixed, briquetted in three sizes (5 × 5, 10 × 10 and 30 × 30 mm.) and roasted. In the roasting plant oxygen or air-oxygen mixture passes through a vessel containing either water for wetting the gas or strong sulphuric acid for drying (according to nature of experiment). The gas then passes through a flowmeter into a tube furnace for preliminary heating and into a reaction furnace containing the batch; this is heated by a.c. and rheostat to the required temperature and controlled by a thermocouple connected up with an automatic potentiometer. Outlet gases pass into a U-shaped tube cooler where the vapours condense and the sulphur is collected. Residual gases pass into the absorber comprising three vessels containing cadmium acetate solution, two of which are fitted with stopcocks for withdrawing samples of gas for analysis (about every 5 min.). Pressure through the system is regulated by means of a water-jet pump. SO_2 content is determined by oxidising with a 0.1 N iodine solution, with the formation of iodic and sulphuric acids, the H_2S being absorbed by the acetate solution. The CdS formed is converted into CuS for analysis, and the oxygen is determined by absorption in alkaline pyrogallol. The experiment is stopped when outlet gases contain only traces of SO_2 or H_2S. The data obtained with these small-scale tests were duplicated with a larger set-up in the laboratory. Below is a summary of the work and results.

Pilot-scale results

The effect of quantitative relation between carbonated pyrites and gypsum on sulphur yield and on extent of $CaSO_4$ dissociation is shown in Table 1. The pyrites contained 15% coal (carbon), whilst the amount of $CaSO_4$ in the mixture varied from 30 to 65%. At the end of 100 to 110 min. roasting products were analysed.

Table 1

$CaSO_4$ content	*Total S separating*	*$CaSO_4$ dissociating, i.e. sulphate S*	*Sulphide S extract*
%	%	%	%
65	49.00	33.50	96.40
60	58.50	40.00	99.00
55	67.00	48.00	99.12
50	70.50	52.50	98.23
45	73.30	56.60	98.63
40	77.30	62.00	97.52
35	78.90	62.50	97.14
30	80.80	66.90	97.82

The air-oxygen mixture blown in contained up to 50% oxygen and the temperature range was 850 to 870°C. It is

evident that the sulphide sulphur result is little affected by the amount of gypsum present. Under the conditions used the sulphur separated out as elemental, H_2S and SO_2. Other sulphur compounds were practically negligible. It is evident, too, that the greater the content of pyrites and coal the greater is the H_2S and SO_2 content of the gas, and also the extent of the $CaSO_4$ dissociation with formation of sulphur. Moreover, it is shown that the presence in the reaction mixture of coal, FeS and Fe_2O_3 (formed by burning FeS) lowers the temperature of $CaSO_4$ dissociation.

The yield of sulphur rises sharply with a temperature increase from about 750 to 900°C., and then much more slowly up to 1,000 to 1,100°C. (99% S). The curve for $CaSO_4$ dissociation with temperature is similar but rather more linear. Table 2 shows the results obtained in burning briquettes of 5 × 5 mm. containing 40% $CaSO_4$ and 60% carbonated pyrites, for about 60 min., with air-oxygen blast (50% each of O_2 and N_2):

Table 2

Temperature, °C. ..	1,100	1,200
Yield of S in gas and elemental, % ..	97.06	98.48
Residual:		
Sulphate S, % ..	2.80	1.40
Sulphide S, % ..	0.14	0.12
$CaSO_4$ dissociation, %	87.80	95.50
Yield, sulphide S, % ..	99.60	99.70

The relation between $CaSO_4$ content and temperature is, of course, important. At a constant temperature of, say, 1,000°C., sulphur yields decline with increasing calcium sulphate. With a fixed dissociation, namely of 75%, time ranging from 50 to 160 min. and temperatures from 850 to 1,300°C., it is again shown that dissociation takes place with rising temperature more quickly with a low than a high $CaSO_4$ content (tests were with 30, 40 and 50%).

The effect of coal content, with temperatures of 875 to 950°C. and the usual air-oxygen mixture, is given in Table 3 ($CaSO_4$, 45%):

Table 3

	%	%
Coal content in batch ..	11	18.55
Total sulphur yield ..	84	89.40
Extent of $CaSO_4$ dissociation (sulphate S)	71.4	79.00
Yield, sulphide S ..	97.5	97.80

With excess coal the $CaSO_4$, even at 850 to 900°C., is reduced to CaS in about 60 min. Yield of elementary sulphur is also increased when more carbon is present. When the briquettes contained 20% alumina, as kaolin, burnt at 900°C., with 50% oxygen in the blast, following results were obtained:

	%
Total sulphur yield	96.50
$CaSO_4$ dissociation	90.85
Sulphide sulphur	97.52

Thus the rate and extent of dissociation is raised by the presence of alumina. As already intimated, with moisture present in the air-oxygen stream, CaO or $CaCO_3$ is formed with H_2S, and sulphur from the latter (reversible reaction). With 10% water vapour in the air-oxygen stream, $CaSO_4$ from 50 to 30% and coal (carbon) from 7.5 to 10.5% (balance pyrites), temperature 900 to 940°C., there is an increase in the yield of sulphide sulphur from 96.14 to 97.8% and of elemental sulphur from 60.45 to 82.8%. At higher temperatures up to 1,150°C., with 40% $CaSO_4$ in initial charge, the sulphur yield may reach 97%.

Yields and composition of the gas phase

Samples were taken for analysis every 5 min. throughout each test which lasted 100 min., during which 100 litres of oxygen-enriched air was blown in. The temperature in the reaction zone was 890 to 900°C. The rate of reaction and formation of sulphur and gas are lowered with increasing $CaSO_4$ content in the mix (or briquettes), but with the addition of Al_2O_3, up to 20%, and so much less $CaSO_4$, the reaction rate and gas formation increase. Any appreciable excess of CO in the gas phase slows up anhydrite dissociation, so that a slight excess of oxygen in the reaction zone is necessary. With a minimum of $CaSO_4$, maximum gas evolution is reached in about 40 min., during which time the carbon has practically all reacted and the sulphide sulphur is in the gas phase.

Curves in a graph show variations in gas composition against time, with a constant batch composition of 40% $CaSO_4$, 51% FeS_2 and 9% coal (carbon), temperature 885 to 900°C. The curve for $CO_2 + SO_2 + H_2S$ reaches its maximum (about 50%) in 10 min. and slowly declines to 10% at the finish. The curve for $H_2S + SO_2$ reaches its peak (30%) in 50 min. and declines again to zero. The curve for oxygen is zero at 45 min. and maximum at 100 min. (about 50%). Oxygen control is important; this gas should be kept at a minimum, at least in the early stages. Moisture in the air blast improved yields of both elemental sulphur and sulphur gases, the content being up to 12%. Coal content was at the same time increased to 12% and FeS_2 reduced to 48%. Content of H_2S in the outlet gas was thus increased at the expense of SO_2, which is thus reduced to elemental S. Under properly maintained conditions, yields of elemental S may thus reach 70 to 83% of total sulphur—increasing with temperature and moisture—though this latter somewhat lengthens the process and probably also reduces need for oxygen enrichment. With wet blast, briquettes of 5 × 5 mm. and temperature 875°C., the time required may be up to 7 hr. The author adds that maximum $H_2S + SO_2$ reached 14.5% with batch composition of 35% $CaSO_4$ and 65% carbonated pyrites.

Some details are given of a larger-scale laboratory test, with briquettes of 10 × 10 mm., for which the time was 12¼ hr. and temperature 810 to 840°C., with wet blast of 10%. Maximum $H_2S + SO_2$ was 14.6%. Elemental S was 32.6% of total S.

Finally, some details are given of the strength and stability of briquettes of varying composition, briquetted under pressures of 50 and 1,000 kg./sq.cm. and burnt at 1,000°C.; one sample including 20% Al_2O_3 gave best strength results (65.4 kg./sq.cm. for low-pressure bricks and 280 kg./sq.cm. for high pressure, in crushing or breaking test). An increase in the carbonated pyrites content lowers the fusion point of the briquettes, and temperatures generally should not exceed 1,150°C.

Soldering watertight copper joints without pre-tinning

A simple method of soldering joints between copper tubing and copper fittings without pre-tinning them is suggested by the Chase Brass & Copper Co., Waterbury, Connecticut. It is necessary to begin with tubing and fittings that have been designed for proper tolerances.

First, the tube ends are cut square with a fine-tooth hacksaw or with blade cutters. The chamfering of the inside and outside tube edges facilitates joining of tube and fitting, in the larger sizes. Steel wool or sand cloth is employed to polish the outer surfaces of tube ends and the inner surfaces of fittings before applying flux. A suitable flux consists of zinc and ammonium chlorides prepared with petrolatum in paste form.

Soft solder is adequate for joints in water lines where temperatures do not exceed 250°F. and where there are no excessive pressures or stresses. Suitable solders include 50/50 tin-lead, 95/5 tin-antimony or other tin-lead alloys.

The soldering of fittings larger than 2 in. may be effected by heating with more than one torch, but greater care is needed to prevent spot overheating. If the flame is moved uniformly over the entire area of the fitting until a point just below the melting point of the solder is reached, large fittings can be conveniently soldered by re-application of heat to limited areas. By applying the flame over an arc of approximately 2 or 3 in., wire solder can be tested for temperature and then flowed into the joint to form a soldering section. By repeating this step-process, overlapping sections can be made until the entire joint has been filled up with solder. Surplus solder is then removed, and the joint allowed to cool.

When joints exceed 4 in. diam., heat is rapidly dissipated, so that best results may be had with an oxy-acetylene torch using a medium-sized tip. For smaller sizes of copper water tube, petrol, butane, propane or air-acetylene torches, or electrical units, may be used.

Plant and Equipment

New brazing technique for stainless steel

When making brazed joints it is essential that the surfaces to be joined are kept clean so that the brazing metal may wet them freely; the necessary cleanliness may be achieved either by the use of flux or by brazing the component in a controlled atmosphere. Fluxes usually have the disadvantage that they need to be completely removed after brazing to prevent subsequent corrosion. On the other hand, brazing of stainless steel in a controlled atmosphere has not always proved consistently satisfactory. A technique whereby the brazing of stainless steels can be carried out in a standard furnace provided with a controlled atmosphere has now been developed by the General Electric Co. Ltd. The process is suitable both for copper-brazing stainless steels and for brazing components using *Nicrobraz* alloy as the filler metal.

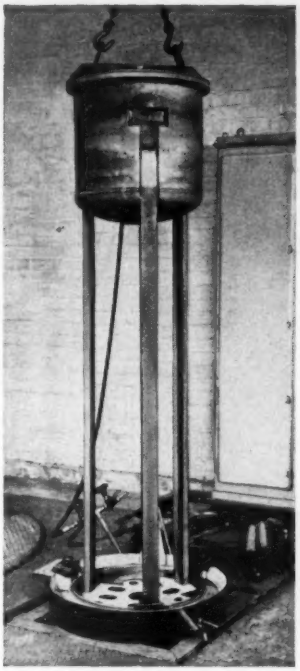
The protective atmospheres most widely used in the process are burnt town gas or burnt ammonia. The brazing of metals which are not easily oxidised, such as steel, may be carried out in these atmospheres, using filler metals such as copper or copper alloys. However, when components of the stainless-steel type are to be treated, it is necessary to maintain close control over the quality of the atmosphere within the furnace chamber. Traces of oxygen, water-vapour or carbon dioxide will form an oxide film on the surface of the components which prevents the liquid brazing metal from alloying with the exposed surfaces and a sound joint being made. Similar considerations apply when the brazing alloy itself is readily oxidised, as is the case with certain high-temperature alloys. If a very dry hydrogen atmosphere is used and if treatment is carried out in a metal container, the surfaces are kept clean and brazing is satisfactory.

The illustration shows the container assembly of a 60-kw. vertical cylindrical furnace, which has been used for the purpose. It has effective loading dimensions of 17 in. diameter by 4 ft. 10 in. deep and can be used for all types of brazing in the temperature range 700 to 1,180°C. The method of operation is as follows:

(*a*) After loading the stainless-steel assemblies on the support casting, the pot is sealed and immediately purged with the dry hydrogen protective atmosphere. If it is considered desirable, the pot may first be purged with nitrogen.

(*b*) The pot is loaded into the furnace and the charge brought to the required temperature in the controlled atmosphere and held at that temperature for between 10 and 30 min., depending upon the brazing alloy being used.

(*c*) The pot is removed from the furnace and cooled under the protective atmosphere.



Container assembly of a 60-kw. furnace.

The holding time at high temperature is short; for most filler metals 10 min. is sufficient, but when *Nicrobraz* is used a suitable holding time has been found to be 30 min.

Heat exchange surface

A new extended surface for heat exchangers has been developed by Sunrod Ltd. It consists of a number of copper rods welded on to a base wall of steel in such a manner that, when used in any form of heat exchanger, an extremely high heat transfer coefficient is obtained. As the base wall is of steel, it is suitable for high working pressures. It is suitable for incorporation in fuel oil heaters, permitting a heater of very small dimensions and weight to be produced.

A heater incorporating the new surface has been made by the same firm. It is of all-welded construction, thereby eliminating leakages; it is free from expansion stresses; the heating element can be withdrawn for inspection without breaking the oil pipe joints, and the oil heating surface is thus completely exposed for any cleaning that may be necessary. These heaters are suitable for oils of all viscosities working at any pressures. This type of heater has been tested at the Pametrada Research Station and a full report on its performance is available.

The Sunrod surface is also incorporated in a range of hot-water and steam boilers ranging from 90,000 B.Th.U. up to 8 million B.Th.U. for hot water and, in the steam range, from 225 to 4,400 lb./hr. at pressures up to 225 p.s.i. The extended surface is used in these boilers as a convection surface and, consequently efficiencies of between 80 and 85% are readily obtained, while at the same time the size of the unit is very small. The boilers are designed for oil, gas and solid fuel firing.

A successful application of this surface can be found in Sunrod economisers, which are applicable to both domestic and industrial boilers. Again, for the reasons explained, these units are extremely small. They offer considerable saving in fuel—in some cases more than 30% can be saved, it is claimed. The units have been especially designed for simple insertion in existing boiler flue pipes.

The new surface and the plants described were shown at the Fuel Efficiency Exhibition held in Manchester recently.

Waste heat recovery

Models of modern waste heat recovery plant were shown at the recent Fuel Efficiency Exhibition by Spencer-Bonecourt Ltd., an associated company of Babcock & Wilcox Ltd.

The waste heat boiler plant, shown by a model, is a twin-drum unit installed in a chemical works, each drum being 10 ft. diameter with a tube length of 15 ft. 6 in. Its distinctive feature is the adoption of extended heating surface, by way of a steaming economiser interposed between the waste heat boiler drums and the induced-draught fan. By this means a higher heat extraction is obtained, resulting in higher steam yield than has hitherto been obtained on waste heat recovery plant employing the straightforward fire-tube boiler drum only, it is claimed.

The plant is designed for a pressure of 250 p.s.i. gauge, operating at a working pressure of 180 p.s.i. gauge. The waste gases enter the boiler drums at a temperature of 500°C. and leave the economiser at around 190°C., resulting in a steam yield of about 22,000 lb./hr. A superheater is installed in the boiler inlet chamber to give a final steam temperature of 250°C. The temperature of the feed water entering the economiser is 70°C.

The gas-turbine unit shown in model form is an entirely new system of waste heat recovery, combining a closed-cycle gas turbo-alternator and a boiler generating low-pressure process steam. The plant is now being erected in a gas works in the Midlands to operate on Glover-West vertical carbonising plant. The main pressurised air heater for the gas-turbine circuit is located in the waste gas collecting flue from the carbonising plant, the waste gases entering at about 800°C. and leaving at about 450°C. The air, heated to about 600°C., is passed to a closed-cycle gas turbine, this system eliminating all possibility of blade fouling. The waste flue

gases leaving the air heater pass to a standard Spencer-Bonecourt waste heat boiler producing about 6,000 lb./hr. of 1-p. process steam. This, taken in conjunction with the output from the gas turbine (about 600 kw. after allowing for auxiliaries), is claimed to have an appreciable improvement in efficiency over the orthodox back-pressure or pass-out steam turbine.

Flow control device

A new flow transmitter, in the form of a non-mercurial manometer, is claimed to have fast, accurate response to rapid change in flow. It operates on the pneumatic balance principle, whereby the force of the differential pressure across the flow orifice —or from any other source—is opposed by the force of air pressure acting in a weigh-beam system similar to that found in analytical balances. Air pressure developed to balance the force thereby becomes a measure of differential pressure or flow and is transmitted by a single air line to a pneumatic receiving instrument in the form of an indicator recorder and/or controller.

The operating principle of the unit is illustrated in the diagram. The low- and high-pressure chambers (A and B) are separated by a flexible diaphragm (C) which is connected to one end of a primary beam (D). The beam extends through a sealing bellows (E), which confines the measured fluid within the high-pressure chamber. Near the bellows is the fulcrum for the primary beam. Toward the opposite end of this beam is a bevel-edged rider (G), which is movable, to provide a range-changing feature, but which can be considered a fixed knife-edge in the operation of the unit.

Differential pressure in the meter body thus creates an upward force on the left-hand end of the primary beam. Because of the intermediate fulcrum on the beam, this force acts downwards on a secondary beam (F) through the bevel-edged rider. As shown in the diagram, the right-hand end of the secondary beam is a fixed fulcrum point, while the other end is linked to a flapper (H). The downward force on the secondary beam thus moves the flapper toward a nozzle (I).

Air pressure from the supply is bled through a restriction into the pneumatic-balance system, which comprises the flapper and nozzle and a balancing bellows (J), as illustrated. Thus, when the nozzle is covered, air pressure builds up in the balancing bellows and an upward force is created in opposition to the downward force due to the differential pressure. In this manner output air pressure from the converter is directly proportional to the measured differential pressure and, by means of a pneumatic receiver bellows, can be transmitted directly in terms of flow or differential pressure readings.

The instrument has a continuously adjustable range from 20 to 200 in. of water. Range-changing needs no special tools, additional parts or part changes and provision is made for protection against over-range. Accuracy is within $\pm 1\%$ of full scale, sensitivity to differential pressure changes is less than 0.1% of scale, and response time averages 3 sec. for 63.2% of full-scale change with 200 ft. of tubing to the receiver.

The instrument, known as the Brown differential converter, is made by Honeywell-Brown Ltd. Weighing only 23 lb., the instrument can be located close to the pressure taps. A complete element could be provided by using the instrument in conjunction with the Brown pneumatic receiver either in the form of an indicating controller, a single-, two- or three-pen recorder or a single- or two-pen recording controller.

Screw-capping machine

A fully-automatic screw-capping machine to handle a wide range of metal and plastic screw caps up to a maximum diameter of 2 in. has been introduced by Autopack Ltd. The machine will maintain output speeds of up to 100/min. and re-setting for different sizes of container or cap can be achieved very quickly and simply. The design is simple and there is no need for maintenance to be done by skilled engineers.

The containers are conveyor-fed into an intermittently rotating rotor which passes them beneath the cap chute fed from an automatic hopper. The caps are placed into position on the containers, given one complete turn as the container passes round the machine, and then screwed down and tightened to a predetermined tension. When the operation is completed the containers are ejected *via* the outlet conveyor.

All working parts are fully guarded and the design of the machine makes it impossible to damage a container or cap or for a jam to occur. Safety devices will stop the machine automatically immediately if it becomes overloaded. Working parts are kept to a minimum and precision construction ensures long life. Liquid or powder filling units can be incorporated on the machine if required.

Electrolytic process for starch splitting

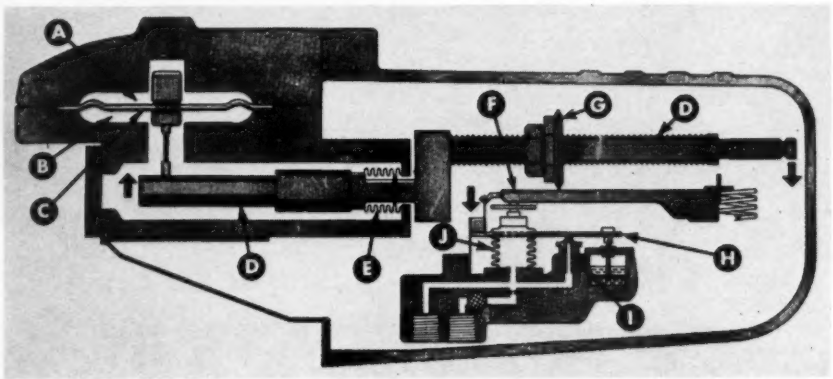
A new continuous electrolytic process for the solubilisation or oxidation of starch has been invented by the Nuremberg firm of A. Hering A.G. In this process starch suspension is fed to an electrolyser, in which the starch molecule is split up readily and under control, chiefly by using the *statu nascendi*. The hydrolytic process can be adjusted to yield wide ranges of viscosity. The process is as follows: Starch suspension of 12 to 18°Be., agitated in the mixing tank with a small charge of NaCl, is passed through a preheater to the electrolyser. The reaction temperatures suitable for this type of starch are controlled automatically, not only in the preheater but also in the cellular electrolyser which is equipped with a central agitator, water-cooled electrodes and a cooling jacket. In addition, acid may be added in controlled quantities to the electrolyser from a tank. The reaction time in the electrolyser is determined by the required degree of hydrolysis and ranges from 10 to 60 min. From the electrolyser the starch solution flows to a water-cooled neutralisation tank which is equipped with an agitator.

The neutralisation itself is controlled by means of a *p*H measuring and controlling device. The electrolytic solution is then separated from the starch by a centrifugal process or by decantation and flows back to the mixing tank for further use.

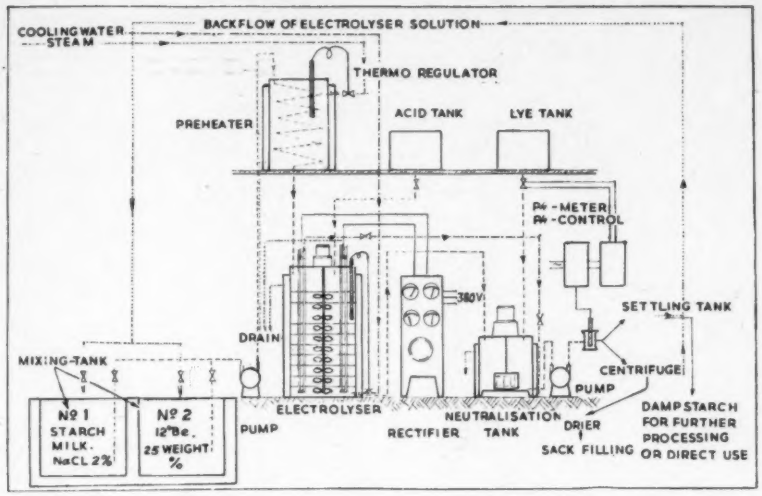
The preheater is usually steam-heated. Overheating of the heat-sensitive starch paste is avoided by automatic temperature control. The power consumption is determined by the required degree of hydrolysis. For example, for the treatment of potato starch a maximum of 0.1 kwh./kg. will be needed. For soluble starch of the lowest viscosity, the requirement is 0.3 kwh./kg. dry starch with a cooling water consumption of approximately 0.5 to 1 cu.m./hr.

The consumption of electrolyte, *e.g.* NaCl or KCl, is 1 to 2% of the weight of dry starch. The process can be automatic or semi-automatic and no attention from skilled personnel is needed.

The process conditions to obtain the



Operating principles of pneumatic-balance differential flow transmitter.



Flow diagram of the new starch electrolyser.

desired finished product are easily determined and can be adapted to the different properties of the many kinds of starch. A small laboratory electrolyser is being built to assist in the determination of process conditions.

The starch electrolyser guarantees splitting to an equal and homogenous degree. Splitting by electrolysis is more speedy than the processes which has been used so far.

Remote indication of pressures, temperatures and mechanical movements

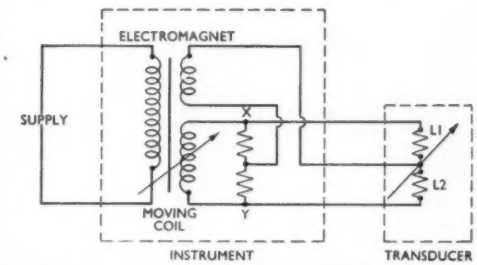
A new system for measuring pressures, temperatures and mechanical movements electrically and indicating the results at a distance has been introduced by Salford Electrical Instruments Ltd. after three years' research and development work in collaboration with the research laboratories of the General Electric Co. Ltd. This new system is a development of the original electro-mechanical converter system and introduces a smaller transducer with a wide range of applications. These include the direct measurement of mechanical movements of 0-20, 0-50 and 0-100 thousandths of an inch by a spring-loaded stylus, the measurement of pressures, utilising a diaphragm or other pressure mechanical conversion device, and indeed the measurement of any quantity which can be converted into a mechanical movement.

The instrument, which is of similar construction to the standard moving-coil switchboard instrument with a 100° scale, may be located at any distance from the transducer, provided the resistance of any one conductor does not exceed 25 ohms. To prevent errors due to stray a.c. pick-up, all three conductors should run within the same cable or conduit. With the standard type of three-core cable the maximum distance between the transducer and the instrument is 1,000 yd., but greater distances are permissible.

If desired, certain types of a.c. potentiometric recorder may be used in place of the instrument, whilst it is possible to switch the output of up to 10 transducers on to one instrument.

Pressure applications. The new system, used with a diaphragm assembly consisting of a beryllium copper capsule brazed into a suitable housing, will find obvious applications in gas works, water works and oil installations, enabling measurements of low pressure line pressures down to 10 in. water gauge to be taken at many selected points and read on indicating dials in a central control or operation room. It is particularly valuable where it is undesirable or inconvenient to run pipework into an indicating position. The transmitter is screwed into the pipeline at the most suitable point for pressure measurement. This point, though ideal for measurement purposes, might otherwise be inconvenient, or even inaccessible for direct reading.

Operation. The system is of a very simple basic design and no valves, barretters or rectifiers are used. A change in electro-magnetic coupling at the transducer end is balanced by a change in electro-magnetic coupling at the instrument. The circuit is shown in the diagram. The voltage between X and Y depends on the relative values of L_1 and L_2 and these depend upon the position of the core in the air gap, *i.e.* on the position of the stylus.



Circuit diagram of a new transducer system for the remote indication of pressures, temperatures and mechanical movements.

The voltage induced in the moving coil from the electro-magnet depends on its angle of deflection. The voltage between X and Y is applied to the moving coil and, since this is free to move, it will take up a position such that the electrical torque is zero. Thus if any change occurs in the position of the core in the transducer, there will be a change in the position of the moving coil and of the indicator pointer.

The magnitude of the voltages and currents in the circuit is of little consequence, and the system is, in fact, a form of balanced electro-magnetic servo system.

Flow meter

The KU mercurial flow meter is the first of a new *Commander* class of meters in which the case and front mechanism are standardised. This enables the user to fit additional 'presentation' features to a meter or to interchange parts between meters and reduce the number of spare parts kept in stock. Pre-calibration of relevant parts increases this flexibility by allowing the user to assemble a variety of instruments from standard units as well as to alter ranges easily.

The new meter, made by George Kent Ltd., is for recording, indicating, integrating and automatic control of the flow of oil, water, air, gas, steam and most industrial liquids; it works in conjunction with a Venturi tube, Dall tube or orifice in the fluid pipeline. Its interchangeable mercury chambers are steel forgings, designed to receive maximum differential pressures of 25, 50, 100, 200, 400 or 600 in. of water (air-on-mercury basis). The new-design float (in the downstream chamber) rises for an increase in differential pressure. The extention of the U-tube is thus downwards, and the easily separable control head is a standard unit. Only a new upstream mercury chamber and U-tube are required for a range change, which can be made on site. An adjustable throttle valve in the downstream leg of the U-tube damps out the effect of a pulsating-flow characteristic. Streamlined over-load valves provide a safeguard against loss of mercury on excess or reverse loads. The control head includes two mild-steel forgings specially designed to reduce the number of joints to a minimum.

The 'presentation' mechanism can accommodate up to two pens and a pointer, the second pen being for pressure measurement from a pre-calibrated Bourdon tube unit mounted in the case. Over-range protection is provided for the pens in both directions of movement. The pointer rotates on the same axis as the pens, indicating on a crescent-shaped, 8-in.-long scale. The pen is an integral part of the pen arm, the whole sliding easily in or out of an aperture on the pen spindle arm and automatically locating itself.

Technical Publishing Today

MR. W. LEONARD HILL'S SURVEY

THE role of a technical and industrial publishing house 'in this technologically exciting mid-twentieth century' was described recently by Mr. W. Leonard Hill, chairman of Leonard Hill Ltd. He was speaking at a cocktail party held to celebrate the presentation to him by the staff of the company of his portrait. Many friends of the company—authors, consultants, advertisers, printers, blockmakers, etc.—were present at the party, which was held at Mr. Hill's town house in Hampstead.

Mr. T. Crosbie-Walsh, a director of the company, pointed out that the portrait has been presented to mark the recent acquisition and occupation by the company of their new building, Stratford House, Eden Street, N.W.1. He briefly reviewed the growth of the company under Mr. Hill's leadership before unveiling the portrait amid general applause.

In responding, Mr. Hill said that he thought his audience would wish him to speak about the company, its achievements and its progress. 'The original development,' he said, 'was in chemistry and chemical engineering with the Chemical Engineering Catalogue, now *Chemical Industries*. The idea of this publication was put forward by Mr. E. E. Newitt, whose son, Prof. D. M. Newitt, F.R.S., was editor of the publication for several years.'

The company's first journal was *Food Manufacture*, the first journal of its kind in the world. 'Then came *Manufacturing Chemist:* although this was by no means the first chemical paper it was the first fine and pharmaceutical chemical paper, and thus impinged on no one else's field and did not in fact offer *merely* another competitor. *Manufacturing Chemist*, again like *Food Manufacture*, retained its solus position for many years. . . . Then came *Paint Manufacture*. There was at that time no paper in any language in the field of surface coatings devoted exclusively to manufacture and disregarding merchanting, retailing and decorating. Then came *Petroleum*, the first journal in Europe to specialise in refining to the exclusion of drilling.

'During the war, partly because it was felt that those young men we were hoping would return to us might not find their metier in the more scientific fields, the company acquired *Building Digest*, *Pottery and Glass* and *Muck Shifter*, the latter being, as you all know, the much-loved old English name for the public works contractor.

'After the war the company returned to its original theme of chemistry and engineering with *Fibres*, *World Crops*, *Dairyman*, *Atomics*, and CHEMICAL & PROCESS ENGINEERING.

'The company's publications now cover industries ranging from the oldest in the world—agriculture—to the very newest—atomics. . . .

Mr. W. Leonard Hill and his portrait.

'Through its journals the company plays a world-wide role in the development of new and improved techniques not only in established and, perhaps, traditional industries, but in the very newest.

'Here are four examples of the latter:

'1. In this country, and indeed all over the world, there is a definite need for increasing knowledge and use of chemical engineering, the principles of which are applicable to a great number of industries. Recognising this need, the company proceeded to stimulate and develop chemical engineering through CHEMICAL & PROCESS ENGINEERING. This journal is increasing in size and influence year by year and more and more chemical engineers of high standing are contributing to it. The steady increase in its advertising pages shows how chemical plant manufacturers recognise this influence.

'2. Atomic energy is obviously destined to exert a tremendous influence on humanity, not only in its military aspects but also in its industrial aspects. We are interested only in its industrial aspects, and in 1950 we launched *Atomics*, the first journal in Europe to deal with nuclear energy in industry.

'3. There is now very active development of man-made fibres, stimulated in Britain by the development of nylon, *Ardil* and more recently *Terylene*, and new techniques in the preparation of natural fibres. Here again was a new field and Leonard Hill Ltd. have entered it with *Fibres* which, while dealing with both natural and synthetic fibres, lays stress on new development in man-made fibres.

'4. Since the war there has been a tremendous interest in agricultural chemicals and in governments' interest in their domestic agriculture, as well as in the development of the less productive areas of the world. One, and only a comparatively minor aspect of this subject, will be known to most people present—that is, pest control products, but what I am considering now is the huge army of specialists, advisers, soil chemists and pest control specialists associated with the universities, doing active work with the research stations and with the plant-breeding stations; add to these the agricultural research councils, and the agricultural advisory services which are perhaps better known in this country as the county agricultural committees. These men are duplicated in every country of the world. They have already, as we all know, raised farming to new standards and increased productivity in percentages that would not have been believed only a decade or two ago. These practical scientists with common interests throughout the world and working closely hand-in-glove around the world had until recently no paper devoted to their highly important activities, until this company produced *World Crops* covering the fields I have described. This paper has taken its place as one of the great international successes.'

After the applause that greeted Mr. Hill's remarks, Dr. L. A. Jordan, Director of the Paint Research Station, rose to thank him on behalf of the guests for the very pleasant ceremony and the hospitality that had been provided.

Among those present were Dr. E. T. H. Hoblyn (Director, B.C.P.M.A.), Mr. C. R. Woods (W. J. Bush), Mr. A. L. Bacharach (Glaxo), Dr. Wm. Mitchell (Stafford Allen), Mr. Gordon Long (I.C.I.), Mr. A. R. N. Roberts (Plant Protection), Mr. Brian Reavell (Kestner), Mr. Porter (Pascall Engineering), Mr. W. P. Evans (May and Baker), Mr. Broughton-Black (Pyrene), and Mr. K. G. Hibbs (Courtaulds).

Electric resistance heating. This is the title of a 180-page, demy 8vo. book, with 170 illustrations, published by the British Electrical Development Association. Starting with the theory of electric resistance heating and the types of elements which may be used, typical examples are then described of electric heating equipment of every type from large heat-treatment furnaces to electric soldering irons. It is the first book to be published on this particular aspect of electric heating. There are 13 chapters dealing respectively with the advantages of electric heating; fundamentals of heat; thermal insulation; electric heating elements; temperature control; electric resistance furnaces; electric salt baths; electric ovens and infra-red heating; soft metal melting; liquid heating; platen, press and roll heating; electric steam boilers and steam raising; and miscellaneous applications. Price 8s. 6d. net.

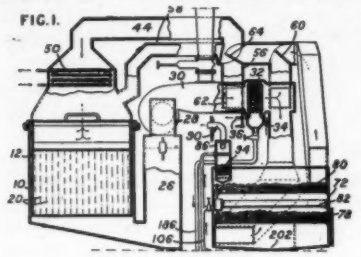
Chemical Engineering Invention

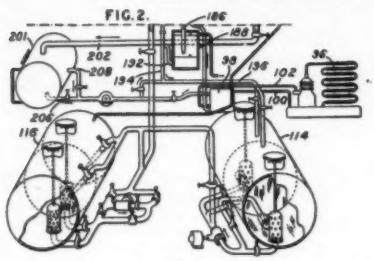
MONTHLY SUMMARY OF PATENT CLAIMS

Recovering solvents in direct-contact condensers

In the process described, solvent is recovered from material treated with an impregnating agent dissolved in the solvent. Hot gas is passed over the material and then through a direct-contact condenser fed with cooling liquid below 0°C. and a surface condenser.

Paper 20 to be impregnated in a basket 12 is contained in an impregnating and drying





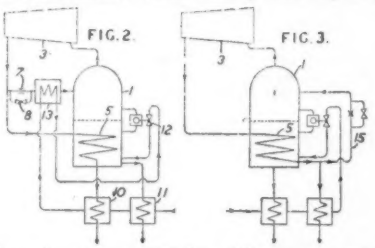
chamber 10 to which bitumen or asphalt dissolved in trichlorethylene is pumped from a storage tank 116 (Fig. 2) and after a time pumped back. Air is circulated by a fan 28 (Fig. 1) *via* ducts 26, 30, 56 and 44 and heating elements 50 and for an initial period also *via* duct 58, bypassing the heating elements 50. Air containing solvent and water vapour expelled from the circulating system passes through a direct-contact condenser 72. This comprises two layers, 78 and 80, of clay rings. Calcium chloride solution at −15°C. flows over layer 78 from a trough 82. It is fed to the trough *via* a pipe 106 and a heat exchanger 98 (Fig. 2) through which a refrigerating medium is circulated *via* pipes 100 and 102 from a refrigerator 96. Calcium chloride solution containing condensed solvent flows from the condenser 72 *via* a pipe 202 to a tank 201 (Fig. 2). The calcium chloride solution forming the upper layer is normally pumped from tank 201 to the trough 82 through a pipe 208 and the heat exchanger 98, but at intervals the solvent forming the lower layer is pumped into a solvent and impregnating agent mixing tank 114 *via* a pipe 206.

The condenser 72 communicates with a container 86 having a vent 90 open to the atmosphere, and containing clay rings 94 fed with calcium chloride solution *via* the pipe 106, whereby remaining solvent vapours are condensed. When air expelled from the circulation system becomes more saturated with vapours, a valve 62 is opened and valves 64 and 60 closed. Some air thus flows to a surface condenser 32 fed with water from pipes 34 and 36. Condensate flows *via* a pipe 186 to a container 188 (Fig. 2) from which solvent is led out *via* pipes 192, 194 and 196 to the tank 114. After some time a valve 60 is opened so that part of the circulating air is first precooled in condenser 32 and then passed to condenser 72. When the solvent recovery period is ended the basket 12 is lifted, the passages through condenser 32 and conduits 56 closed and fresh air forced through the units 20.—656,299, *Isoleringsaktiebolaget Wmb.*

Turbo-compression evaporators

The plant comprises an evaporator having its vapour space connected to the inlet of a multi-stage, axial-flow, rotary compressor. The outlet of this is connected to the heating unit within the evaporator and also, either directly or indirectly, to the vapour space of the evaporator. A feed preheater is heated by the condensate discharged from the heating unit. The use of this type of compressor with evaporators of small size is made practical by the additional connection.

The vapour space of evaporator 1 (Fig. 2), is connected to the suction side of compressor 3. The delivery side of the compressor is connected to heating coil 5 within the evaporator, and also to the vapour space of the evaporator *via* restriction 7, valve 8 and heat exchanger 13. The proportion of compressed vapour passed to the vapour space of the evaporator is varied by valve 8 to suit any given output. Heat exchangers 10 and 11 are heated by the condensate from coil 5 and by the



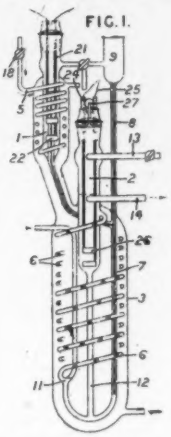
blow-down respectively. All three external heat exchangers are used to preheat the feed supplied to the evaporator. The feed-supply valve 12 is controlled by a float in dependence on the liquid level within the evaporator.

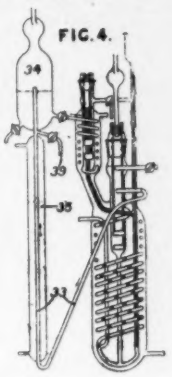
In the modification shown in Fig. 3, the delivery side of the compressor 3 is connected to the vapour space of the evaporator 1 indirectly through the heating coil 5, a valve-controlled line 15 being provided for the purpose.—652,888, *G. & J. Weir Ltd. and E. N. King.*

Gas analysis

The proportion of a constituent in a gaseous mixture is determined continuously by absorbing the constituent in an electrolyte and comparing the electrical conductivities of the electrolyte before and after absorption of the constituent.

The process is effected in an integral unit (Fig. 1) comprising a reference cell 1 and a measuring cell 2, both of which contain a pair of platinised platinum elec-





trodes 22, 26, and both of which are integrally mounted in a constant-temperature jacket 3. The electrodes are connected by wires 21, 25, to a Wheatstone bridge, the spacing between electrodes 22 being constant but that between electrodes 26 being adjustable by means of a rack-and-pinion device 24, 27. Electrolyte is fed to reference cell 1 through coiled pipe 5 and overflows into capillary tube 7, by which it is fed through pipe 12 and coiled tube 6 to measuring cell 2. The gaseous mixture under test enters the coiled tube 6 at 11 and bubbles through the electrolyte in the tube until it reaches cell 2, where the residual gas and used electrolyte are led off by pipes 13, 14, respectively. Flow of electrolyte is regulated by a valve 18 provided with a plurality of ports of different cross-sectional area and is measured by a graduated capillary tube 8. The capillary tube 8 is in communication with the atmosphere at 9.

In a modification (Fig. 4) the electrolyte flows in a closed circuit by thermosyphonic effect and is regenerated in pipe 33 by means of a heating jacket 35. An inactive gas may be introduced at 39 to urge the thermosyphonic motion and the expulsion of the desorbed gases from bulb 34. When employed to determine the proportion of SO_2 and H_2S in gaseous mixtures, the electrolyte may be monoethanolamine and the regenerant in jacket 35 may be steam.—641,978, *Manufactures de Produits Chimiques du Nord Etablissements Kuhlmann.*

The photos show *(left)*: sifting, mixing and spraying plant with automatic feeder and elevator ('Veevic' plant); and the feeding, elevating and grinding plant with dust extraction.

New Plant Installed by Liverpool Borax Co.

THE Liverpool Borax Co. Ltd. have recently carried out the reconstruction and modernisation of their Liverpool works, completely re-equipping their plant with up-to-date machinery.

The premises in which the plant has been erected have been occupied by the company for over 50 years and, at the end of the last war, these were completely rebuilt on the original site as a two-storey building. Products for their subsidiaries, Feedwater Specialists Co. and Andrew Maxwell, are manufactured at this factory.

Feedwater Specialists, as the name implies, specialise in the treatment of water for steam-raising plant and other industrial purposes (*Algor*). It is well known that different formulae are necessary in this field to meet the varying conditions found in different parts of the world, and the company modifies these formulae to suit the individual needs of its various clients. Plant is also supplied and erected.

The Andrew Maxwell subsidiary is mainly concerned with paint-cleaning materials (*Veevic*), industrial cleaners for the food and dairy industries (*Lamol*), and bituminous products and protective coatings (*Rito* and *Ritolastic*). Liverpool Borax also specialise in products for the wool-scouring industry.

Some of the raw materials of these companies require to be disintegrated. This is done in a special rotary tooth breaker situated on the first floor and is then conveyed automatically by means of elevators to the mills situated on the same floor. From here the ingredients, which are now of a uniform fineness, are fed by gravity to the mixer situated on the ground floor, thus ensuring intimate blending of the different chemicals making up the batch. The finished product is then drawn off into suitable containers, which naturally vary according to demand and whether despatch will be for the home market or for export.

New spraying and mixing plant has been installed for manufacturing the wool-scouring products, paint cleaners, etc.

The mixers situated on the first floor are fed by a feeder-elevator, the material being tipped into this from the first floor and elevated into the mixer.

Spraying apparatus is arranged so that correct quantities can be added to the mixer accurately. This is done by a series of storage tanks; the liquid is sprayed into the mixer through nozzles by means of pumps. The final mixed material is then fed by gravity to the automatic fillers situated below.

The major part of the plant has been supplied and erected by Wm. Gardner & Sons (Gloucester) Ltd.

Magnetic filter

In the Chemical Engineering Division of the Atomic Energy Research Establishment preliminary tests have been carried out to investigate the characteristics of porous filter beds, consisting of fine ferromagnetic particles supported by electromagnetic fields on relatively coarse metal grilles inside a 2-in. o.d. stainless-steel tube. The results of the tests are discussed in a report by D. F. Kelsall (H.M.S.O., 2s.).

Satisfactory filtration tests were carried out on freshly precipitated barium sulphate through a bed of fine alumina supported by a ferromagnetic bed. A comparison was made with a similar bed of alumina supported on a medium-grade glass sinter.

It is considered that the small-scale tests were successful enough to warrant more detailed experimental work on a larger scale. The number of the report is AERE CE/M 54.

New portland cement process

An improved process for manufacturing portland cement has been patented in the U.S., and is claimed to combine the advantages of the wet and dry processes, using petroleum distillate instead of water.

Development was based on the fact that, while the advantages of the wet process were due to the presence of a mobile liquid which facilitated the grinding, blending and other operations, the disadvantages could be traced to one or more of the physical and chemical properties of water. Some other liquid was indicated which would remain liquid over a long temperature range, would not react with water or with the compounds present in cement raw materials, would have no dissolution, a boiling point of approximately 300 to 600°F., low latent heat of vaporisation and would be reasonably available at an economical cost. A petroleum distillate was found to meet the requirements.

Tests, using this distillate, indicated that the liquid could be recovered almost completely by distillation, and that the same supply could be used repeatedly with no build-up of undesirable elements, in contrast to the water suspension of the wet process. In addition, any of the distillate remaining in the raw mix would burn in the kiln, thus contributing to the heat input. The results so far obtained are said to show many superiorities over existing dry and wet processes.

There remains to be accomplished pilot-plant runs and the design of any special equipment units that may be found desirable. However, it appears that the plant layout will consist very largely of units now on the market.

With the new process, it is claimed that dry plants can now have the uniformity of product previously restricted to wet plants, while wet plants can retain all their present advantages and at the same time greatly reduce fuel consumption per barrel and increase production.

The new process is applicable to clinker as well as to raw materials. It is claimed to allow the manufacturer to produce cement with the uniformity of a wet process, blend two or more types of finished cement together to produce another, and so on, within wide limits. While it is recommended that the process be applied to both raw mix and cement, it can be applied to either one separately.

World News

GREAT BRITAIN

Six committees will help raise chemical productivity

Six area committees which will help manufacturers of heavy chemicals to raise their productivity have been formed by the Association of British Chemical Manufacturers and have started to function. The committees will encourage firms to follow the suggestions for higher productivity made in the report of the Heavy Chemicals Team which visited the U.S. in 1952.

Each committee comprises four members from the management and technical side of the industry, three from trades unions and two Team members. The committees, with the names of their chairmen, are:

Bristol (to cover S.W. England and S. Wales): Mr. D. M. G. Sneddon (National Smelting Co. Ltd.).

London: Mr. A. H. N. Wells (A. Boake, Roberts & Co. Ltd.).

Glasgow (for Scotland): Mr. W. A. C. Chrystal (John & James White Ltd.).

Birmingham (for the Midlands): Mr. J. K. Bottomley (Albright & Wilson Ltd.).

York (to cover N.E. coast): Mr. W. K. Hall (I.C.I. Billingham).

Manchester (N.W. area and N. Wales): Dr. W. A. Hayward (Monsanto Chemicals Ltd.).

Natural gas search

A start has been made upon the Gas Council's £1-million natural-gas prospecting project. The exploration work is being done by the D'Arcy Exploration Co., Anglo-Iranian's prospecting subsidiary. It began last month at Aldbrough, about 10 miles from Beverley, south-east Yorkshire. The survey will extend westwards for about 40 miles to Market Weigaton. Similar work has started at Stixwould, Lincs., and other surveys will be carried out in the south of England and in Scotland. The first attempt to drill for natural gas will be made at Cousland, near Dalkeith, this month, when four 6-in. holes will be taken down to 2,000 ft.

Conferences for chemical engineers

Food, synthetic fibres and oxidation processes are the subjects of three conferences to be held in March and May.

Food. 'Chemical Engineering in the Food Industry' is the title of the first conference, which is being held by the Chemical Engineering and Food Groups of the Society of Chemical Industry at the Wellcome Research Institution, London, N.W.1, on March 18 and 19. The 11 papers to be presented will cover such subjects as storage, bulk transport and handling of liquids; handling of powders; storage and transport of sugar; mixing, grinding and sifting; heating, evaporation and dehydration; cooling and freezing; sterilisation and pasteurisation; and instrumentation.

Fibres. The Plastics and Polymer Group of the S.C.I. are organising the second conference on 'The Chemistry and Physics of Synthetic Fibres.' It will be held at the Institution of Electrical Engineers, London, W.C.2, on March 24, 25 and 26. Twelve papers will be presented and among the topics will be chemical denaturation of groundnut protein and fibre formation; some aspects of crystallisation; and cellulose acetate as a raw material for fibre formation.

Oxidation. The conference on 'Unit Processes of Oxidation' will take place at The Hague on May 6 and 7. It is being sponsored by the Institution of Chemical Engineers, the Chemical Engineering Group of the Society of Chemical Industry, the Koninklijk Institut van Ingenieurs (Royal Institution of Engineers) (Chemical Engineering Group) and the Koninklijke Nederlandse Chemische Vereniging (Royal Netherlands Chemical Society)(Section for Chemical Technology).

British and Netherlands committees have been appointed for the preparatory work of the conference. The British committee consists of Prof. F. H. Garner (Chairman), Mr. E. Le Q. Herbert, Mr. A. M. Clark, Prof. M. B. Donald, Dr. F. A. Freeth and Mr. R. C. Odams (Secretary). The Netherlands committee includes Prof. Dr. H. I. Waterman (Chairman), Prof. Dr. D. W. van Krevelen, Dr. J. C. Vlugter and Mr. H. Verschoor (Secretary).

In view of the necessity to limit the subject, the unit processes of oxidation have been chosen, while particular stress is being laid on the chemical engineering aspects of these processes. The organising committees have invited a number of universities and industrial concerns in England, Germany and the Netherlands to contribute papers. Promises have been received for papers dealing with the oxidation of aliphatic and aromatic hydrocarbons and with the manufacture of tonnage oxygen.

Requests for further information should be addressed to R. C. Odams, the Institution of Chemical Engineers, 56 Victoria Street, London, S.W.1.

Committee to control fuel prices?

The setting up of an independent fuel advisory committee whose main function would be to supervise the price structure of the National Coal Board was recommended by Dr. F. M. H. Taylor (chairman and managing director, Thermocontrol Installations Ltd.) in a paper presented to the Institute of Fuel in London recently.

Dr. Taylor said that, by fixing prices of the raw material supplied to the gas and electricity industries, which were in competition with raw coal, the N.C.B. was able to control the progress of those industries. Some form of independent supervision of the N.C.B. price structure in relation to vital industries was therefore desirable and in the national interest.

The proposed advisory committee would also ensure that prices charged for gas and electricity were truly related to the costs of production, and could advise the Minister regarding savings likely to be achieved by fuel-economy schemes involving capital expenditure. It could also ensure stable coal prices justifying the installation of special plant for burning low-grade fuels.

New engineers' tool factory

The new engineers' tool factory of Edgar Allen & Co. Ltd. at Shepcote Lane, Tinsley, began operation recently. The factory has been built to manufacture many types of tools, including butt-welded cutting tools, precision-ground form tools, tungsten carbide tools and tips, high-speed steel toolholder bits, *Athyweld* deposit-welded tools and high-speed steel-faced wood-working knives, etc.

The factory has been laid out on the most modern lines for progressive mass production, on a separate plot of land just beyond the existing large trackwork manufacturing department at Shepcote Lane. It is a single-story building, 230 ft. × 160 ft. wide, covering 37,000 superficial ft. of floor area. The factory has been built to meet steadily increasing demand, extension of the original engineers' tool department being no longer possible without encroachment on neighbouring departments.

Chemical engineering careers explained to schoolboys

Continuing its good work of getting youth interested in chemical engineering as a career, the Institution of Chemical Engineers recently held a meeting to which it invited 180 schoolboys and masters from grammar and public schools in the London area. Prof. M. B. Donald, Ramsay Professor of Chemical Engineering in the University of London and Chairman of the Institution's Education Committee, gave a brief talk on the profession and the opportunities which it offers. Mr. E. Le Q. Herbert, general manager of Shell Refining & Marketing Co. Ltd. and Member of the Council of the Institution, then introduced the film 'The Stanlow Story,' which showed the construction of one of Britain's new oil refineries involving a great deal of chemical engineering.

After the film, boys and masters mingled informally with members, and a team of chemical engineers, distinguished by lapel badges, answered further questions.

As was reported in our September 1953 issue, the Institution has issued several hundred copies of the brochure, 'Careers in Chemical Engineering,' to schools, colleges, youth employment officers, etc.

NEW APPOINTMENTS

★ **Mr. H. McNeil** has been appointed deputy managing director of Babcock & Wilcox Ltd. He spent his early career in New Zealand and Australia and came to England in 1931. He joined Babcock & Wilcox and for the first two or three years was employed in the Erecting and Service Departments. Subsequently he spent three years in the main works of the company at Renfrew, returning to London to take the position of deputy chief engineer and subsequently that of general manager. He was elected to the board of the company in 1950.

★ **Mr. J. Stewart Robertson** has been appointed general manager of Babcock & Wilcox. He served his apprenticeship in engineering with the General Electric Co. Ltd., joining B. & W. in 1935. He represented the company in New York from 1946 until 1950, when he returned to the U.K. and was appointed manager of the Commonwealth sales department. He was made assistant general manager in December 1952.

★ **Mr. R. V. Arnfield,** B.Sc., A.R.I.C., has joined Premier Colloid Mills Ltd. as technical representative for the counties of Yorkshire, Lancashire, Cheshire and Northumberland. He was previously with Powell Duffryn Technical Services Ltd.

★ **Major A. G. Saunders** has been appointed President of the British Tar Confederation for 1953-54. Other appointments are: **Mr. C. E. Carey,** Hon. Treasurer; **Mr. R. H. E. Thomas,** Chairman of the Executive Board; and **Mr. S. Robinson** and **Mr. H. F. H. Jones,** Vice-chairmen of the Executive Board. The executive board consists of ten representatives nominated by the Association of Tar Distillers, the British Coking Industry Association and the Gas Council, and one representative nominated by the Low Temperature Coal Distillers' Association of Great Britain Ltd.

British technologist awarded American research medal

Mr. W. C. Bell, of Stewarts & Lloyds Ltd., has been awarded the American Iron and Steel Institute Medal for 1953 for a paper entitled 'A Review of European Operating and Technical Practices.' The medal is awarded annually for a paper of special merit and importance to the American iron and steel industry. This is the first time it has been given to anyone other than a United States citizen.

Mr. Bell is a local director of Stewarts & Lloyds and joint director in charge of research and technical development, including planning and new construction of iron and steel works throughout the company.

Society of Engineers' centenary

A visit to the Lafarge Aluminous Cement Co.'s works at West Thurrock, Essex, on May 6 is included in the Society of Engineers' plans for commemorating its centenary this year. The Society's celebrations will open on May 4 with a conversazione, followed on May 5 by a business session devoted to the presentation of papers dealing with 100 years' progress in civil, mechanical, electrical and aeronautical engineering. The climax to the celebrations will be the centenary banquet in the historic Fishmonger's Hall, beside London Bridge and close to an early meeting place of the Society.

Members of the Society in Scotland and in Australia will hold separate celebrations.

Shell distillation trays

A licence to design and supply *Turbogrid* distillation trays has been granted to Metal Propellers Ltd., who have now started manufacture of these trays.

A distillation tray of this type, as made and supplied by W. J. Fraser Ltd., was described in our October 1953 issue. Patented by Shell, *Turbogrid* trays are made and supplied by a number of firms.

Equipment for N.A.T.O. oil projects

Contracts for oil storage facilities and pipelines for the North Atlantic Treaty Organisation's defence programme are to be put out to international tender among member countries under a new scheme. Hitherto, contracts under N.A.T.O.'s *Infrastructure* (common defence projects) programme rarely went outside the countries in which the installations were to be provided. The programme includes airfields and military installations as well as oil projects and up to now it has cost £400 million.

British firms interested in the oil projects can obtain certain other information from the Ministry of Fuel, quoting reference P.E. 804/46/5/2.

EUROPE

International rubber diploma

At a meeting of the International Education Committee in Paris recently the establishment of an international diploma for rubber technicians was agreed. Preliminary negotiations had already led to an agreement to establish an equal technical level of education in all collaborating countries of a standard comparable with that of the Licentiateship of the Institution of the Rubber Industry in London.

The diploma is to be awarded on passing the examination set and assessed by the board of the British Institution. General agreement has been reached regarding requirements in preliminary and professional education and the scheme will come into operation forthwith in Norway, Sweden, Denmark, Holland, France, Belgium, Western Germany, Switzerland, Italy and the United Kingdom.

This is believed to be the first instance of a British professional examination being accepted as the basis for an international diploma award.

NORWAY

Atomic generator planned

At the Atomic Energy Institute at Kjeller, work is now concentrated on designs for an atomic generator with a capacity of 5,000 kw., according to Director Gunnar Randers. The uranium reactor at Kjeller is now operating five days a week, and in the last year has supplied 800,000 kwh. of heat. Continuous production of radioactive isotopes has begun; two-thirds of these are exported. Norwegian and Swedish agricultural research workers at Kjeller are carrying out radiation tests with barley and other grain, said Randers.

FRANCE

Franco-German alcohol proposal

A proposal under which France would supply 500,000 hectolitres of alcohol to the West German firm, Chemische Werke Huels A.G., of Marl, near Recklinghausen, has been submitted by the French Alcohol Producers' Association to the authorities.

Under the proposal, a French firm would invest 3,000 million francs in the production of synthetic rubber by the Chemische Werke Huels A.G., to which it would supply the 500,000 hectolitres of alcohol at 24 francs/litre. In exchange, France would receive 12,000 tons of this rubber p.a. at 210 francs/kg. A long-term contract to this effect may be concluded for either 12, 17 or 25 years.

DOMINICAN REPUBLIC

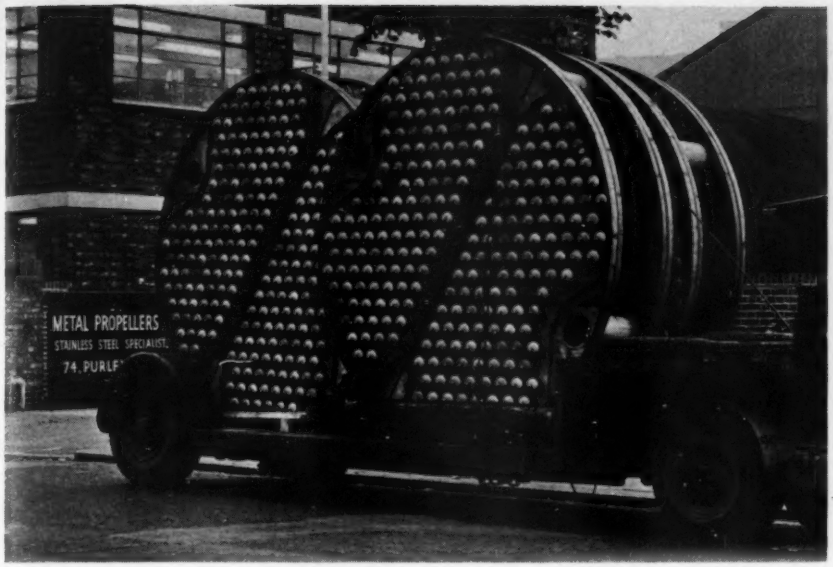
Furfural-from-bagasse project

The South Porto Rico Sugar Co. of New York is planning to build a $7-million plant at La Romana, Dominican Republic, to make furfural from the sugar-cane waste, bagasse. The plant will be constructed and operated by a new subsidiary company, Central Romana By-Products Co.

Studies of the process for producing furfural have been carried out with the Quaker Oats Co., which for the last 30 years has been the leading producer of the chemical in the U.S. Now South Porto Rico Sugar have entered into an agreement with Quaker Oats and will benefit from the latter firm's technical knowledge when it starts operations. In return, Quaker Oats will get a royalty based on a percentage of the sugar company's profits from the furfural business over a period of 10 years. At the end of that time, Quaker Oats will have an option to buy a limited minority stock interest in the subsidiary or subsidiaries manufacturing the chemical.

The Central Romana By-Products Co. has signed a long-term contract with E. I. du Pont de Nemours & Co. and will sell to du Pont a ' very substantial portion ' of its production for 10 years. Du Pont will then have an option to extend the contract for another five years.

The new plant is expected to be in operation by the middle of 1954.



SPECIAL BUBBLE TRAYS

Six 10½-ft.-diameter stainless steel bubble trays, made by Metal Propellers Ltd., ready for dispatch to a large chemical works in the north of England. Most bubble trays made by the company are of Glitsch 'truss-type' design and are delivered 'knocked-down,' for erection on site, but those shown are of solid one-piece construction to meet special process requirements.

URUGUAY

Fish meal elaboration plant —tenders called for

The Servicio Oceanografice y de Pesca (S.O.Y.P.) have called for tenders for the supply of plant for the elaboration of fish meal and oil as follows:

The plant shall be of 'dissolvent' type (non-inflammable) with recuperation equipment, and capable of producing fish meal of the following characteristics: humidity, less than 10%; ash, less than 22%; residual oil in the meal, maximum 20%; maximum acidity in the oil, 2% expressed in oleic acid. The output of the plant shall be approximately 8 tons of raw material to be processed per shift of 8 hr.

Notwithstanding the above requirements for the equipment which shall operate on a 'dissolvent' (non-inflammable) base, the S.O.Y.P. will accept tenders for industrial plant which, although operated in a different manner from that for which tenders are invited, guarantees products (fish meal and oil) of excellent quality, without producing unpleasant odours during the industrial process.

To avoid unpleasant odours from the raw material to be processed, the plant, in one single operating unit, must include a hermetic chamber for storage of raw material. The plant, by means of a device which the manufacturers shall consider adequate, shall take the raw material from the chamber, avoiding handling it in the ambient air. This chamber shall be of 20 tons capacity.

The closing date for the receipt of tenders is January 29 and a maintenance-of-offer guarantee of Ur. $500 is required.

U.K. firms are reminded that tenders should not be submitted direct to official or semi-official Uruguayan organisations, but must be submitted through properly appointed local agents. A list of firms who have expressed their willingness to act on behalf of U.K. firms not represented in Uruguay is available from the Export Services Branch of the Board of Trade, Lacon House, Theobalds Road, London, W.C.1.

JAPAN

Zinc refineries' increased capacity

Two re-equipped zinc refineries, belonging to Mitsui Metal Co. and Mitsubishi Metal Mining Co., will start operation this month. Mitsui have installed vertical retort equipment, designed by the Singmaster & Breyer Co., U.S.A., with a capacity of 500 tons/month of distilled zinc. The company is also planning to install additional equipment eventually.

A spokesman for the company said that, with the new vertical retort process, manpower will be reduced to one-fifth, purity will be 99.5% compared with 98.5% previously and consumption of coal will be less than half.

Mitsubishi have installed a flue solid calcining furnace of American design which will enable them to produce 560 tons of electrolytic zinc and 3 tons of cadmium monthly.

NEW ZEALAND

Tenders for pumps wanted

A call for tenders, contract No. 50, has been issued by the Auckland Metropolitan Drainage Board for the supply and delivery of either: (*a*) three centrifugal pumps each of 350 and 500 gal./min. for 73.5 and 78.5 ft. head, respectively; or (*b*) one centrifugal pump of 350 gal./min. for 73.5 ft. head, and two centrifugal pumps of 850 gal./min. for 96.5 ft. head. All pumps should be complete with starters, motors, sluice valves, reflux valves, suction and delivery piping, intake bellmouths, taper sections and specials, and sundry parts in order that the complete pumping plant can be connected to the rising drain.

The pumping station will handle foul sewage from a separate system.

Closing date for receipt of tenders is 10 a.m., February 1. Tenders should be addressed to the Chairman, Auckland Metropolitan Drainage Board, P.O. Box 208, Auckland, New Zealand, endorsed on the envelope 'Tender for Contract No. 50.'

Further information can be obtained from the Export Services Branch of the Board of Trade, Lacon House, Theobalds Road, London, W.C.1.

Paper mill put to work

The Kinleith mill of New Zealand Forest Products Ltd. has started production of kraft industrial paper from home-grown pine-tree pulp. This mill, which cost £1,350,000, completes the integration of the company's £7-million saw mill, pulp and paper mill project (see CHEMICAL & PROCESS ENGINEERING, October 1953, p. 336).

It will produce a wide range of heavy, medium and light kraft papers and operate over a speed range of from 100 to 1,100 ft./min., depending on the grade of paper.

Its maximum capacity is about 80 tons/day (25,000 tons p.a.).

The pulp supplied by the adjacent pulp mill is treated in batteries of continuous beaters and refiners and, after screening to remove all except the best fibres, is piped to the paper-making machine.

The plant is entirely British, as are the majority of key operators who were brought specially from the U.K. and Australia. It is believed to be the first paper mill in the Southern Hemisphere using woodpulp produced entirely in the country of establishment.

The paper made at Kinleith will be sent to the company's Multiwall bag and container factories at Auckland, replacing the imported paper which has hitherto been used.

Large quantities of paper will also be supplied for the use of New Zealand box-makers.

The mill will operate continuously for 24 hr./day and will cease working for only brief periods during the year for maintenance.

UNITED STATES

Sulphur mine in marshes goes into operation

Production has started at Freeport Sulphur Co.'s new Garden Island Bay mine at the mouth of the Mississippi River. At peak operation the mine is expected to yield 500,000 long tons of sulphur annually, which makes it the largest single sulphur-mining development anywhere in the world since 1933.

Garden Island Bay, 100 miles south-east of New Orleans in remote and desolate marshland, is one of four new salt dome projects that have resulted from Freeport's long-range exploration and development programme. The undertaking required $14 million to carry out because of costly engineering and construction problems. The mine site can be reached only by boat —an hour-long trip from the nearest Mississippi delta road—or by seaplane. The only other large industrial plant within a 75-mile radius is another sulphur plant, Freeport's Grande Ecaille mine, built in the marshland 20 years ago.

Before construction could begin at Garden Island Bay the marsh site of cane, grass and water hyacinth, from 1 to 2 ft. above the level of the nearby Gulf of Mexico, had to be filled with hundreds of thousands of cu. yds. of mud. Several thousand pilings, 85 to 90 ft. long, had to be driven into the soft clay subsoil for the power plant foundation. The pilings support a 16-in. concrete mat carrying 16-ft.-high concrete cells. The main floor of the plant is at this level, a necessary precaution against high water from storms and hurricanes.

To melt the sulphur, which is embedded in the caprock of a salt dome 1,750 to 1,850 ft. below the surface, the plant is designed to pump 3½ million gal. of superheated water (325°F.) into the deposit every 24 hr.

For its water supply, Freeport taps the Mississippi, but the water must be taken from the river when salt intrusion from the gulf is at its lowest point—usually from February to June—and stored in two earthen reservoirs carved out of the marsh. These reservoirs occupy an area a mile square and are capable of holding nearly a billion gallons of water.

The mining area is more than a mile from the power plant which heats the water, as well as tempering and service water and compressed air which lifts the molten sulphur to the surface. The molten sulphur, freed of air and metered at the relay station, is pumped directly into insulated tank barges and transported 50 miles up river for storage at Port Sulphur.

New reforming catalyst

Development of a new platinum reforming catalyst has been announced by American Cyanamid Co. Although production of the new catalyst has been on a pilot-plant scale so far, it is claimed to have important advantages for the petroleum refining industry in that it performs with better-than-usual selectivity, has good activity stability and very high octane barrel rating.

The catalyst will be used first in the new 'ultraforming' process which has been developed by the Standard Oil Co. of Indiana and can be modified so as to make it suitable for use in all types of platinum reforming units. Production of the new catalyst should begin in May.

New fibre plant

The Industrial Rayon Corporation is to erect a $5-million plant for the production of a nylon-type staple fibre at Covingdon, Virginia. The plant is scheduled for completion late this year.

The new fibre, it is reported, can be spun independently or in combination with other fibres. It is stated to have a very high tensile strength and good elasticity. Initial plant capacity will be some 6 million lb. annually.

Sulphur-extraction project

The Texas International Sulphur Co. plans to build a plant near San Felipe, Mexico, to extract crude sulphur from ore mined in nearby concessions. The plant will use the autoclave process, which is described as a batch, rather than a continuous, operation in which the ore is melted under pressure in a closed vessel.

The price of the commercial-grade crude sulphur obtained from the San Felipe deposits, on the Lower California peninsula, will be easily competitive with Gulf Coast sulphur in all markets, according to the company.

New cellulose rayon

Rayonier Inc. have announced development of a new type of chemical cellulose which, company officials predict, will result in improved rayon for tyres, fabrics and other widespread textile applications. The new product, *Raycord X*, was developed especially for use in high-stretch rayon-spinning techniques.

The new product is described as a high-alpha cellulose made by the sulphite process. Rayonier claim that it opens the way to high-tenacity rayon yarn for tyre cord with strengths superior to those in current use, and staple fibre and yarn for viscose rayon fabrics possessing better tenacity and washability than those at present manufactured.

The company is ready to produce the cellulose at the rate of 300,000 tons p.a. at its Fernandina, Florida, and Gray's Harbor, Washington, plants.

It is stated that it is possible to stretch the filament 100% and more in spinning, compared with 30% for conventional rayon and up to 60% for regular tyre yarns. The company considers the new product a complete replacement for blends of cotton linters and other wood cellulose types.

The price for the new cellulose pulp is to be $195/ton, the same as the company's current pulp, *Rayocord*. Regular rayon pulp is about $185/ton.

Engineers see corrosion problems on tour

Actual corrosion problems as experienced in practice by 37 companies were inspected by 205 engineers registered for the third biennial Permian Basin tour sponsored by the National Association of Corrosion Engineers. The headquarters for the tour were in Odessa, Texas.

Three separate tours were conducted simultaneously. Each morning those on the tour divided into three groups, boarded buses and spent the day inspecting equipment. In the evening, all participants gathered in one group where each of the three tours was discussed. This allowed each engineer to gain some benefit and knowledge from the other two tours he could not attend.

At each scheduled stop on the tour, the corrosion history and performance of equipment on display was given in written form to each member of the tour. In one case, performance of cement-lined pipe installed in 1942 was given. When concrete particles from a cement-lined pipe clogged check valves in a gathering system, corrosion engineers met the problem by replacing the concrete-lined pipe with transite pipe. The replacement pipe has given very satisfactory service. The gathering system was on the Magnolia Petroleum Co.'s Dora Roberts lease.

On the Humble Oil & Refining Co.'s J. E. Parker lease, they inspected the interior of a 1,000-bbl. bolted steel tank. In September 1946 the tank was coated with the primer and three coats of liquid vinyl plastic. The deck was galvanised prior to coating. The tank had been inspected on previous Permian Basin corrosion tours. The 1949 N.A.C.E. corrosion tour found the sides of the tank in excellent condition, but the deck had several pinpoint blisters evidently caused by hydrogen sulphide. A sand layer prevented inspection of the tank bottom. When inspected on the corrosion tour of 1951, the coating was found to have withstood corrosive action exceptionally well. However, engineers on this year's corrosion tour found a few blisters.

Examples of Carlon 'B' pipe successfully used as a gathering line, and use of ammonia as an inhibitor were also seen at other sites.

New thermoplastic material

A new form of methylstyrene from which plastics and resins of greater heat resistance can be made is now being produced in experimental qualities by American Cyanamid Co. Plans for larger manufacturing facilities are still in a very early stage. As they stand at the moment, they call for a petrochemical-type operation in which toluene, derived from petroleum sources, would be reacted with acetylene produced from natural gas. The chemical derived from this reaction would be subjected to catalytic cracking to produce methylstyrene.

Polymers produced from methylstyrene

have shown significant properties in a number of applications. These include injecting moulding compounds, surface-coating resins and low-pressure laminating compounds of greater heat resistance. These polymers used as injection moulding compounds will find the same wide range of applications as polystyrenes.

Powder metallurgy studied by European experts

The latest uses and production methods in powder metallurgy have been studied by a team of experts which arrived in New York on September 30. The team, whose mission has been organised under the technical assistance scheme of the Organisation for European Economic Co-operation, comprises 28 participants from seven European countries: Belgium, Denmark, France, Germany, Italy, the Netherlands and the U.K.

The experts, divided into four groups, visited industrial undertakings all over the U.S.A. during their five-weeks' tour. They will shortly report on the possibilities of increasing European productivity in an industry which has reached a high degree of development in the United States.

Commercialisation of lignin products

The West Virginia Pulp & Paper Co. has formed a new division to broaden the commercialisation of its lignin products. At present, commercial quantities of lignin are being used in asphalt emulsion, textile dyes, ceramics, oil-well drillings muds, as a dispersing agent in rubber, as an extender in rubber latex compounds and as an expander in negative plates of storage batteries.

Monsanto phenol plant in operation

The Monsanto Chemical Co. has begun production at its new phenol plant in California. The $4-million plant has an annual capacity of 20 million lb. of phenol.

TURKEY

New fertiliser project

Agreement has been reached between the Turkish Ministry of Reconstruction and a new company formed by a group of banks for the construction of a new fertiliser factory at Kutahya. The company has a capital of T£30 million, while the cost of installing the plant is put at T£70 million.

Production capacity is scheduled at 100,000 tons annually.

INDIA

New paper mill

A mill for the manufacture of paper and strawboard has been opened in the Chanda district in Madhya Pradesh. The project, which has been included in the private sector of the Five-Year Plan, is designed to manufacture quality printing and writing papers at the rate of 20 to 25 tons/day.

Extensions to Sindri fertiliser factory

Global tenders have been invited for the erection of plant and machinery for the manufacture of urea and ammonium nitrate as part of the 100 to 150 million rupee Sindri fertiliser factory expansion plan. A mission of factory officials, after visiting various countries to find out what progress had been made in the manufacture and use of mica urea, submitted a report to the government suggesting a daily production of between 35 and 60 tons of urea. Proposed daily ammonium nitrate production would be around 100 to 150 tons.

CUBA

Ore separation plant wanted

The British Embassy at Havana has reported that the Minas de Matahambre, in the Province of Pinar del Rio, are interested in purchasing a plant for separating a complex ore containing copper, zinc and pyrites with an output of 50 to 60 tons/day. The company believes that the flotation method will prove the more efficacious for their undertaking, but are prepared to study arguments for the gravitation method.

U.K. firms interested should communicate as soon as possible with the Cuban firm, making, if possible, an offer to supply plant on the basis of the requirements described above, quoting, of course, prices in U.S. dollars, either f.o.b. United Kingdom port including packing or, better still, if they can do it accurately at short notice, c.i.f. (Havana). Letters should be addressed to the president of the Cuban company: Senor Ernesto Romagosa, Banco del Caribe S.A., Paseo de Marti y Refugio, Havana, and copies sent to the company's engineer, Sr. Enrique Ruiz-Williams, at the same address.

MEETINGS

Institution of Chemical Engineers

January 30. Annual General Meeting followed by 'Some Aspects of Biochemical Engineering,' by B. Edgington, 2.30 p.m., The University, Edmund Street, Birmingham.

February 2. 'Sedimentation and Fluidisation,' by J. F. Richardson and W. N. Zaki, 5.30 p.m., Geological Society, Burlington House, London, W.1.

Society of Chemical Industry

January 11. 'Synthetic Detergents,' by G. C. Hampson, 7 p.m., Chemistry Lecture Theatre, The University, Leeds 2.

January 14. 'The Stereochemistry of *cyclo*Hexane Derivatives,' by D. H. R. Barton, 7.30 p.m., North British Station Hotel, Edinburgh.

January 19. 'Titanium,' by N. P. Inglis, 6.30 p.m., Birmingham and Midland Institute, Paradise Street, Birmingham 1.

January 19. 'Adventures in Synthetic Fibres,' by D. Traill, 7.30 p.m., Golden Lion Hotel, Stirling.

January 20. 'Manufacture, Properties and Uses of Titanium,' by E. Stables, 7 p.m., College of Further Education, Widnes, Lancs.

January 20. 'Manufacture of Iron and Steel,' by D. J. O. Brandt, 6.30 p.m., King's College Chemistry Lecture Theatre, Strand, London, W.C.2. Joint meeting with the R.I.C.

January 28. 'Synthetic Rubbers,' by F. A. Jones, 7.30 p.m., Town Hall, Preston, Lancs. Joint meeting with the R.I.C.

January 28. 'Polymerisation and its Reversal,' by F. S. Dainton, 6.30 p.m., The University, Manchester. Joint meeting with the R.I.C. and the Chemical Society.

February 1. 'Production and Development of Chemicals for the Rubber Industry,' by Dr. J. W. Barrett, 6.30 p.m., Chemical Society's Rooms, Burlington House, Piccadilly, London, W.1.

Chemical Engineering Group

January 12. 'Engineering and Microbiological Processes,' by F. E. Warner, 5.30 p.m., Geological Society's Rooms, Burlington House, Piccadilly, London, W.1.

Corrosion Group

January 20. 'Metallurgical Aspects of Dry Corrosion,' by L. B. Pfeil, 6.30 p.m., Chemical Society, Burlington House, Piccadilly, London, W.1.

January 21. Exhibition and Conversazione, 6.30 p.m., Battersea Polytechnic, Battersea Park Road, London, S.W.11.

Plastics and Polymer Group

January 19. 'Some Chemical and Technological Aspects of Silicone Resins,' by P. Griffin, 6.30 p.m., Chemical Society's Rooms, Burlington House, Piccadilly, London, W.1.

Chemical Society

January 22. 'Aromatic Substitution,' by Prof. M. J. S. Dewar, 4.30 p.m., Chemistry Department, The University, Birmingham.

January 25. 'Some Recent Progress in Natural Product Chemistry,' by Prof. D. H. R. Barton, 5 p.m., University College, Leicester.

Institute of Fuel

January 12. 'New Carbonisation Processes under Development and their Relation to Established Practice,' by D. T. Barritt and T. Kennaway, 5.30 p.m., Waldorf Hotel, Aldwych, London, W.C.2.

January 26. 'Refractory Recuperators,' by F. H. Cass, Dr. N. L. Franklin and Prof. A. L. Roberts, 5.30 p.m., Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1.

January 28. 'Industrial Drying with Particular Reference to the Problems of the Paint and Foundry Industries,' by A. M. Lehmann, 6 p.m., James Watt Institute, Great Charles Street, Birmingham 3.

Institute of Metals

January 14. Discussion on 'The Corrosion and Preservation of Metals,' 7 p.m., Liverpool Engineering Society's Rooms, The Temple, Dale Street, Liverpool.

January 22. 'Evolution in Extraction Metallurgy,' by Prof. C. W. Dannatt, 7.15 p.m., King's College, Newcastle.

February 4. 'Germanium and Silicon,' by R. W. Douglas, 6.30 p.m., 4 Grosvenor Gardens, London, S.W.1.

Institution of Rubber Industry

February 2. 'Recent Developments in Rubber Machinery,' 7.15 p.m., Midland Hotel, Station Street, Burton-on-Trent.

Fertiliser Society

January 21. Papers on sulphuric acid: 'Flash Roasting,' by W. H. Coates; 'The "Kachkaroff" Process'; 2.30 p.m., Tudor Room, Caxton Hall, Caxton Street, Victoria Street, London, S.W.1.

Royal Institute of Chemistry

January 10. 'The Production and Properties of Zirconium and Titanium,' by G. L. Miller, 7 p.m., Technical College, Brighton.

January 14. 'Fluorine Compounds—A New Branch of Chemistry,' by Dr. R. N. Haszeldine, 7.30 p.m., College of Technology, Leicester.

Incorporated Plant Engineers

January 14. 'Tobacco Processing,' by E. W. Watson, 7 p.m., Roadway House, Oxford Street, Newcastle-on-Tyne.

January 19. 'Corrosion,' 7 p.m., Bull Hotel, Rochester.

January 20. 'Instrumentation,' 7 p.m., Scottish Building Centre, 425-427 Sauchiehall Street, Glasgow.

The Leonard Hill Technical Group—January

Manufacturing Chemist—Coumarin Anti-coagulant Drugs; Ampholytic Detergents; American Montan Wax; Effluent Treatment at May & Baker's Factory; Organo-Phosphorus Insecticides; Biochemical Engineering; Progress Reports: Fertilisers, Disinfectants and Cosmetics.

Paint Manufacture—Preparation of Drying Oils from Saturated Fatty Acids; How Inks Dry; Collapsible Tubes; A History of Paints and Varnishes in Great Britain, Part 3; The Determination of Particle Size; Paint Technology and the Law.

Food Manufacture—The Irish Jam and Marmalade Industry; Progress Article: The Baking Industry; How an American Research Organisation Operates.

World Crops—World Agricultural Production in 1952-53; Land Reclamation Schemes in India; Cocoa in the Belgian Congo; Potato Root Eelworm.

Petroleum—Heat Exchangers: Their Maintenance and Reconditioning; Removal of Hydrogen Sulphide from Hydrogen Gas; Current American Practice; The Variation of the Elastic Constants of Rocks with Frequency; New Grease Plant for Canada.

Fibres—The Use of Detergents in the Wool Textile Industry; Growth of the Australian Flax Industry.

Building Materials—Preparation and Uses of Laminated Timber; Lead in Building Construction; Swedish Building Methods; Stabilising of Sizes of Wood and Wood Products by a New Process.

Muck Shifter—Soviet Construction Equipment; Work at Mingaladon Airport, Rangoon.

Seasonal Greetings

We acknowledge with great appreciation the seasonal greetings sent to us in the form of calendars, diaries and Christmas cards by our many friends and in particular: Advanx Tyre & Rubber Co. Pty. Ltd., Sydney, Australia; Thos. Broadbent & Sons Ltd.; Innoxa (England) Ltd. and Scientific Pharmacals Ltd.; George Lewi & Partners; Vacuum Oil Co. Ltd.; Webb Corbett Ltd.; and Widnes Foundry & Engineering Co. Ltd.

CHEMICAL & PROCESS ENGINEERING

ENQUIRY BUREAU

Stratford House, 9 Eden Street, London, N.W.1

Readers requiring names of suppliers of raw materials, machinery or finished products should complete this form and attach it to their business note-heading. Please state approximate quantities required.

We wish to know names and addresses of suppliers of the following:

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For office use only. No. Date

Danish Chemical Combine is 60 Years Old

DENMARK'S sole producer of sulphuric acid and superphosphate, Dansk Svovlsyre-Superphosphat Fabrik, recently celebrated its 60th anniversary. The company, which has a capital of 25 million Danish crowns, has a capacity for 420,000 tons p.a. of superphosphate (18%). The demand for its products may be measured by the Danish superphosphate consumption of 387,000 tons in 1938-39 and 395,000 tons in 1947-48.

There are three works which produce sulphuric acid and superphosphate—at Norresundby, Fredericia and Kalundborg—in addition to a sulphuric acid works at Kastrup. The three sulphuric acid/superphosphate works each have a capacity of 140,000 tons p.a. of superphosphate. At Kalundborg the sulphuric acid is manufactured in a tower system, whilst at Norresundby and Fredericia lead chambers are used. The Fredericia works will, however, shortly be converted to the tower system.

Although fertiliser manufacture is its main enterprise, the D.S.S.F., through its subsidiary companies, is interested in the manufacture of a range of chemicals.

One of the subsidiaries has ten factories where animal offal is processed into technical fat, glue, bone meal and sundry animal feeding stuffs.

Another, A/S Kemisk Industri, has three works for tar distillation (including the processing of by-product naphthalene, technical cresol and benzole) and the manufacture of road tar, bitumen emulsions, bituminous insulating materials, roofing felts, glass wool and also a series of chemicals such as calcium sulphydrate, fruit tree washes, lime of sulphur and colloidal sulphur. In close co-operation with this company is another which has 11 factories producing exclusively bituminous road materials and also owns a granite quarry on the isle of Bornholm.

Much the same manufacturing activities as are carried out by these last two companies in Denmark are undertaken by the fourth subsidiary, A/B Mataki, at various factories in Sweden.

Most of the plant in the D.S.S.F.'s factories is of German construction, but some of the newer equipment has been built by the company itself in its own engineering works, in co-operation with engineering contractors and consultants.

The company's other manufactures include fluorine compounds, petroleum spirit, town gas, liquid gas, solvents and candles—this last being a most important commodity in Denmark, as in Sweden. The D.S.S.F. claims to make the finest-quality candles which have no smell and do not drip or smoke.